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WILD AND DOMESTIC UNGULATE INTERACTIONS IN THE BOB CREEK AREA, SOUTHWESTERN ALBERTA

by

©

BJORNE PETER BERG

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

WILDLIFE PRODUCTIVITY AND MANAGEMENT

DEPARTMENT OF ANIMAL SCIENCE

EDMONTON, ALBERTA

SPRING 1983

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled WILD AND DOMESTIC UNGULATE INTERACTIONS IN THE BOB CREEK AREA, SOUTHWESTERN ALBERTA submitted by BJORNE PETER BERG in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE.

ABSTRACT

The area around Bob Creek, a tributary of the Oldman River in southwestern Alberta, is an important range for native ungulates and domestic livestock. The interactions in resource use among elk (*Cervus elaphus nelsoni*), mule deer (*Odocoileus hemionus*), and cattle (*Bos taurus*) are of particular concern to management. This investigation described the patterns of resource use of each ungulate, examined their differences and their implications for management.

By analysing the patterns of resource use, a number of range sites, which were important to each ungulate, were located and identified. Each range site was small, usually less than 25 ha in size, but some sites were contiguous. The greatest proportion of animals observed were on or adjacent to these sites throughout the course of the study. For elk and cattle, there were no specific topographical or vegetational features which were common to all sites. Thus, there were no altitudes, slopes or habitat features which could be used to specify where elk or cattle would range. The most important sites for elk wintering in the study area could be described only as those which had less snow cover. The most important sites for cattle through the summer grazing season could be described only as those which were close to water. On the other hand, the most important range sites for wintering mule deer could be described specifically. They tended to be sites, smaller than 25 ha in

size, on southern and western exposures, associated with coniferous and shrub vegetation, which had less snow cover than surrounding areas.

Each ungulate had a relatively specialized diet. Elk and cattle relied heavily on grasses, in particular the fescues (*Festuca* spp.). Mule deer relied primarily on Douglas fir (*Pseudotsuga menziesii*).

In a comparison of the patterns of resource use it was found that elk and cattle used different land areas and they were present at different seasons of the year; their resource use was divided in terms of space and time. Elk and mule deer ranged different land areas and had different diets; their resource use was divided in terms of space and forage. Mule deer and cattle had different diets; their resource use was divided in terms of forage. Whether these divisions were a result of competitive or synergistic interactions could not be deduced.

Because the distribution of domestic livestock is easily affected by changes in management (eg. fencing, herding, water and salt placement) elk and cattle were felt to have the narrowest division in resource use. Management programs to improve the productivity of the Bob Creek Area will be successful primarily if they increase the number of important range sites available, and secondarily if they improve the forage productivity on existing sites.

ACKNOWLEDGEMENTS

A number of individuals and groups contributed their time and effort to this endeavour. I especially wish to thank the A7 Ranch, Sandy Porter, his neighbour Ronald Nelson, Alex Dodds and the sportsmen from Lomond, for their hospitality, interest, and support. Dr. R.J. Hudson, John Walker, Eldor Berg, and a number of friends aided in the field work and their efforts were sincerely appreciated. I am also grateful to B. Markham, D. Yule, D. Conrad, M. Anderson, the late G. Maduram, my supervisor Dr. R.J. Hudson, and my supervising committee, Dr. A. Bailey, Dr. G. Mathison, Prof. P. Murphy, W. Wishart, and the late Dr. D. Gill for their helpful advice, criticism and encouragement. Thanks are due as well to Y. Hudson for translating my handwriting into type, and to K. Davis for turning stick figures into fine graphics. And, without Deborah Berg's complete participation, I may have only ever had a pile of paper in the basement.

The financial and logistic support provided by the Alberta Government's Fish and Wildlife Division, the Forest Service, and the chairmen of the University of Alberta's Department of Animal Science, Dr. L. Milligan, and Dr. R. Berg, was greatly appreciated.

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1. INTRODUCTION

1.1 Multiple Use and Management

In 1877, Fred Kanouse trailed the first range cattle into southern Alberta to stock the range at Fort Macleod. Dairy cattle, horses, and a few beef steers had been brought in earlier, but only horses had escaped onto the open range (McEwan 1964).

Kanouse's 22 head augured a new era in the use of Alberta's rangelands. Indiscriminate hunting soon annihilated free-ranging plains bison and decimated most other wild ungulate populations (Kelly 1913, p. 112-125). By 1890 there were over 200,000 head of livestock on southern Alberta range (Kelly 1913, p. 249).

Efforts to conserve lands and wildlife over the succeeding 100 years created a source of conflict in the management of these rangelands, especially where Crown (public) lands were concerned. The conflict related directly to two competitive demands of resource users:

1. preservation and restoration of the original resource for esthetic values;
2. development and utilization of the resource for economic benefits.

In order to balance these demands, the philosophy of multiple use was adopted and ratified in diverse legislative and policy documents (e.g., the *Multiple Use Sustained Yield*

Act in the United States and *A Policy for Resource Management of the Eastern Slopes*, in Alberta).

The recently released policy for wildlife (Alberta Fish and Wildlife Division, 1982) established the Alberta Government's intent to protect and maintain wildlife populations. Effective and justifiable strategies for managing native ungulates are forthcoming. If the government remains committed to a multiple use policy on Crown grazing lands, equally effective and justifiable strategies will also be required for domestic livestock management.

In particular there is a need to determine the optimal mix of ungulate species in a multiple use situation. Presumably, one ungulate's effect on the productivity of another could be deduced, if the right information is gathered on each ungulate's resource use. Both ungulates could then be managed in a manner that optimizes their productivity. Accordingly, a substantial body of research has been created that describes the effect of livestock resource use on wild ungulates (Mackie 1978, Nelson 1982). A frequent conclusion is that livestock compete with wild ungulates for resources that are in short supply. However, there is some evidence that the productivity of each ungulate may be enhanced (facilitated) by certain management programs (Anderson and Scherzinger 1975, Holechek 1981, Scotter 1980), a conclusion that infers considerable scope for integrating ungulate use.

The joint management of wild and domestic ungulates is especially crucial to the use of Crown grazing lands on the eastern slopes of the Rocky Mountains. This region of Alberta is subject to a variety of conflicting demands that are not easily integrated.

One example of the problem exists in the area around Bob Creek, a tributary of the Oldman River in southwestern Alberta. Cattle have grazed the area for 100 years; resident mule deer and elk populations have grown in size and conflicting importance over the same period.

1.2 Previous Studies

Are there significant interactions between wild and domestic ungulates in the Bob Creek Area? Previous studies have examined some aspects of this question, primarily in relation range and wildlife management.

Mitchell and Cormack (1960) conducted range surveys in the Bob Creek Area during the 1950's and concluded that increases in range use were not warranted or desirable. They suggested that sedges (*Carex* spp.), rushes (*Juncus* spp.), and little club moss (*Selaginella densa*) were replacing grasses. A government forage resources study conducted investigations on the area from 1969 to 1973. Major winter use areas appeared to be in fair to good condition, but the results were not analyzed. Vriend *et al*. (1975) reviewed the requirements of wild ungulates in the area, and discussed

their migration patterns. Ungulate range use and diets were not evaluated.

1.3 Objectives

This study examined ungulate range use and interaction in the Bob Creek Area. Specifically, it was designed to accomplish the following objectives:

1. describe the range use and diets of elk, mule deer and cattle in the Bob Creek Area;
2. evaluate the interactions between ungulates, their range use, and the implications for management.

Range use was quantified by recording the distribution and activity of animals. Specific resource parameters (eg. altitude, vegetation) were assigned subjective classifications so that animals would not be obviously disturbed by data collection. Because the distribution of variation within a resource parameter was subjectively estimated, statistical procedures were limited to those capable of handling nominally-scaled or nonparametric data.

The arrangement of this treatise follows the statement of objectives. The study area, vegetation, and range use are described in Chapters 2, 3, and 4, respectively. Interaction and resource division (partitioning) are evaluated in Chapter 5, and the constraints on management are assessed in the finale, Chapter 6.

2. THE BOB CREEK AREA

2.1 Introduction

Extending north from the International Boundary, the eastern slopes of the Rocky Mountains cover about 10% of Alberta. Most of it is Crown (public) land which has been divided into a number of national and provincial parks, ecological reserves, wilderness areas, forest reserves, Indian reservations, and grazing leases. Major commercial interests include the timber, mining, and oil industries.

This investigation was centred on the Bob Creek drainage in southwestern Alberta (Figure 2.1). Bounded by the Whaleback Ridge to the east and Spring Creek to the west, the study covered an area of approximately 11,600 ha.

2.2 Grazing History

Early information on ungulates in the Bob Creek Area is widely scattered, and usually anecdotal. Bison are generally acknowledged to have disappeared from southern Alberta during the 1870's, and stories of diseased or dying elk along the Oldman River are also cited for this decade (A. Russell pers. comm.). Carr (1976) felt that a few elk were present on the Oldman River in the early 1900's. However, most ranchers southwest of the Highwood River had never seen an elk until the late 1930's (A. Russell pers. comm.). In the national parks, populations of wild ungulates increased

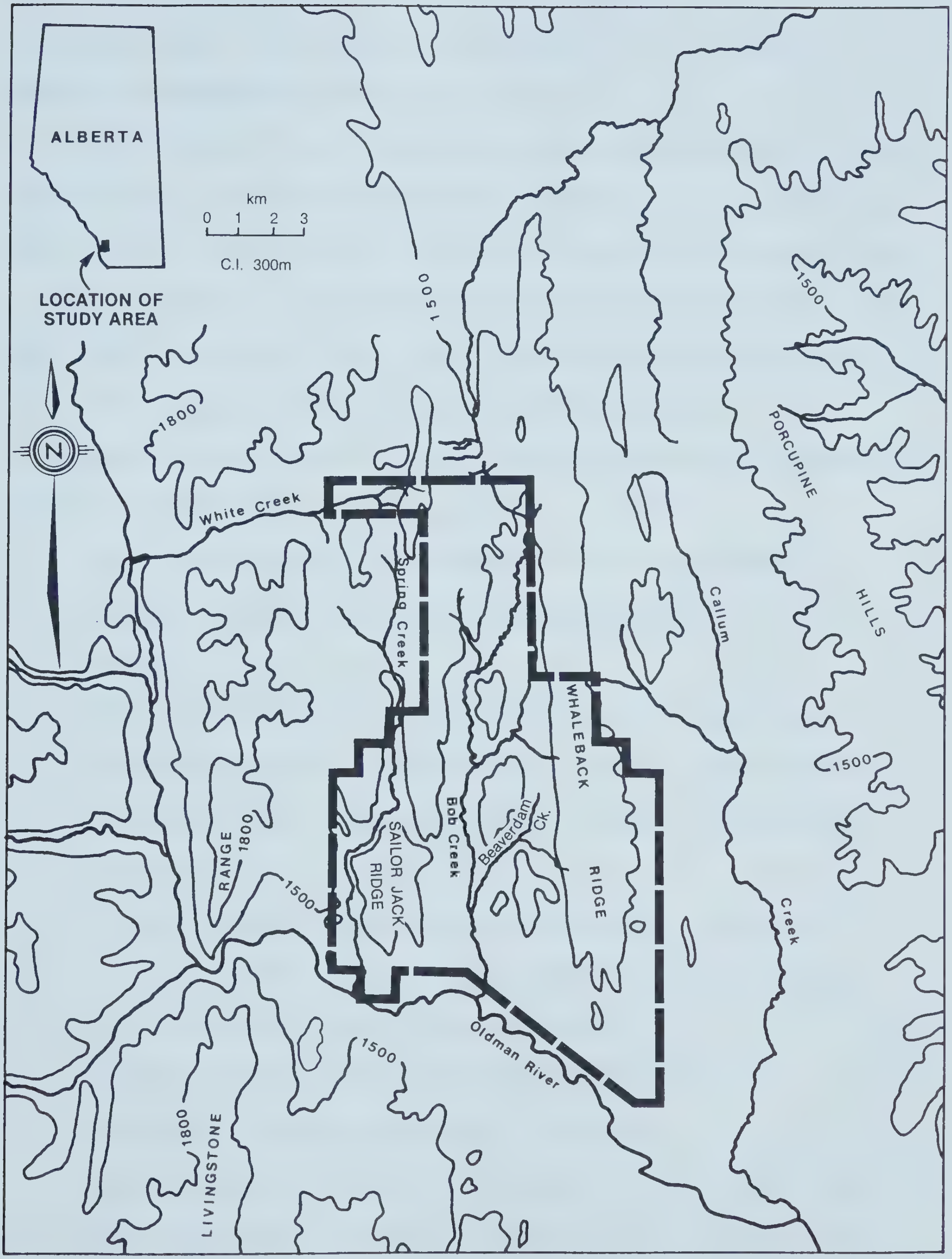

Figure 2.1 The Bob Creek Area in southwestern Alberta.
(Townships 10 and 11, Ranges 2 and 3, West of 5th Meridian)

until 1943 when their levels peaked (Cowan 1945). Later investigations found severe competition for forage on a seriously depleted range (Cowan 1947).

The Waldron Cattle Ranch Ltd. was established in 1883 and granted a 100,000 acre lease adjacent to the Bob Creek Area in 1884. Its ledger lists 9,240 head of livestock on 1 January 1886; 11,429 head on 1 December 1888; and 12,377 head on 31 December 1890. In 1906, it is acknowledged to have had about 20,000 head on 400,000 acres.

Range conditions in these early years were regarded as ideal for the continuous grazing of livestock.

> "The native grass, knee deep...and the chinook winds...helped keep the pasture open all winter..."
>
> "The grass seems to be of a variety containing an exceptional nutritional value, for the cattle fed on the Waldron Ranch range have topped the Chicago market."
>
> "...there being no fences to restrain a ranche's (sic) livestock, the animals could roam and graze as far off the lease as they chose."
>
> (Waldron Ranch Files, Correspondence and Clippings, Glenbow Archives, Calgary).

Several severe winters (1886/87, 1906/07, and 1918/19) decimated herds on a number of ranches, including the A7 Ranch and the Waldron. The weather was blamed for the losses in the winters of 1886/87 and 1906/07 but mange, fences,

prairie fires and overstocking were also implicated, especially for the latter winter (Kelly 1913, p. 376). Summer drought and winter grazing were blamed for the losses in 1918/19 and subsequently a 15 May to 15 December grazing season was imposed on the Forest Reserves (Barnes 1920). Stocking rates were also reduced from 10 acres per head per year commonly given before 1890, to 20 and 30 acres per head by 1918. Winter grazing, however, continued in some regions into the 1920's; 800 head of A7 cattle wintered on the Bob and Spring Creek Cattle and Horse Division from 15 December 1922 to 15 May 1923.

From 1950 to 1977, stocking rates for livestock gradually declined from 6,286 AUM's (Animal Unit Months) to 4,061 AUM's on the Bob Creek and Lower Spring Creek allotments. Late winter surveys of big game in the Livingstone Range-Porcupine Hills Region have rarely counted more than 1200 elk or 600 mule deer. Table 2.1 summarizes the ungulate populations specific to the Bob Creek Area within this region. Elk populations appear to show some stability, averaging 612 animals per survey. Mule deer populations appear to be more variable. Grazing conflicts have escalated in recent years, despite the decline in use.

Table 2.1 Average animal use in the Bob Creek Area, 1950 to 1978.

Period	Cattle (AUM)	Elk (Head)	Deer (Head)
1950-1954	5072	----	----
1955-1959	4809	----	----
1960-1964	4687	853*	----
1965-1968	4747	1154	----
1971-1974	4544	566**	261**
1975	4095	473	183
1976	4195	656	249
1977	4061	699	32
1978	----	688	194

Source: Alberta Forest Service and Fish and Wildlife Division operational files.

* Average for 1962/1964.

** 1974 only.

2.3 Geomorphology

The Bob Creek Area is considered a part of the foothills physiographic region (Karpuk and Levinsohn 1980). The classification is based on the fact that the same bedrock is found in the Rocky Mountains to the west but it exhibits less height and distance displacement. Geological thrusting along at least three major faults has created a series of north-south ridges within the area. Sedimentary bedrock outcrops are present on most ridgecrests and in a few places along the creeks.

Topographical variation is high: level terraces are found on glaciofluvial deposits near the Oldman River; moderately rolling to undulating till blankets are found in the valleys; and bedrock is often exposed on steep ridges. Elevations range from 1370 m in the valley bottoms to 1875 m on the ridgecrests. Maximum slopes of 70% occur on the study area, but most slopes range between 15% and 30%.

2.4 Climate

The airflow patterns over the study area are strongly affected by the rock wall of the Livingstone Range, and the Gap (a break in the wall on the Oldman River). The prevailing west wind funnels through the Gap giving moderate to strong winds down the Oldman River valley. Strong winds develop on the east side of the Livingstone Range because of the abrupt change in altitudes encountered to the west

(450 m per km rise). These winds break up low-lying cloud formations, and blast the ridgecrests but leave the valleys relatively calm (Janz and Storr 1977). Mean windspeeds greater than 30 km/hr probably occur between 40% and 60% of the time (Leggat 1979). The wind redistributes snow, increases evaporation rates, and augments the effect of chinooks. (A chinook is commonly accepted to be a prevailing west wind with a temperature of 4°C or greater from December through to the end of February.) Chinooks are frequent, averaging 1 day out of 3 during the mid-winter period (Longley 1967).

Between 55% and 60% of the total annual precipitation in the region falls from May to September. Winter precipitation rates from 2 Sacramento storage gauges and a snow course near the study area provided some information on snowfall. The lowest snowfall on record was reported during the winter of 1976/1977 (Table 2.2).

Figures 2.2 and 2.3 show the temperature and snow conditions on the study area during the study period. January to April 1977 was warmer (higher mean maximum and minimum temperatures and a greater incidence of chinook conditions) than the same period in 1978. The snow depth on both north-facing and south-facing slopes was low in 1977, high in 1978. Snow depth exceeded 4 dm for only a brief period in January 1977, and only on north-facing slopes. In contrast, snow depth exceeded 4 dm from mid-January to mid-March in 1978 on all slopes.

Table 2.2 Snowfall measured by Sacramento storage gauges and snowcourses near Bob Creek, Alberta.

Location	Winter Snowfall (mm of water)					
	1975/ 1976	1976/ 1977	1977/ 1978	Max.	Min.	Annual Mean
Sacramento Gauges						
Livingstone Gap	165	114	279	417	114	236
West Porcupine	178	127	191	335	79	216
Snowcourses						
Streeter Creek						
14Y10	89	41	86	130	41	89
14Y13	155	58	117	251	58	170
14Y14	104	36	99	160	25	102
14Y15	74	30	86	135	30	97

Data source: Environment Canada operational reports

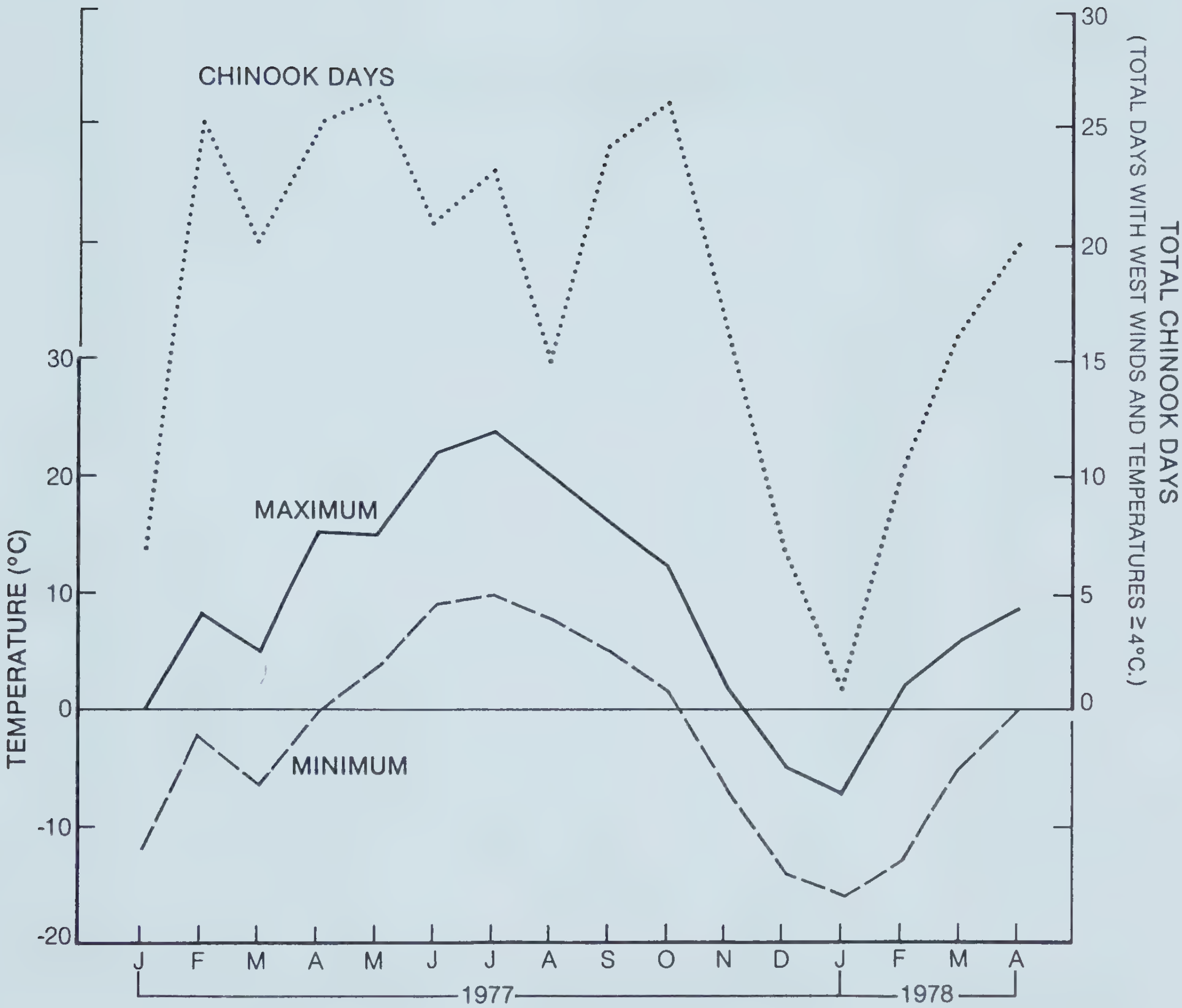

Figure 2.2 Mean maximum and minimum monthly temperature (°C), and total days per month for chinooks and prevailing west winds in the Bob Creek Area.

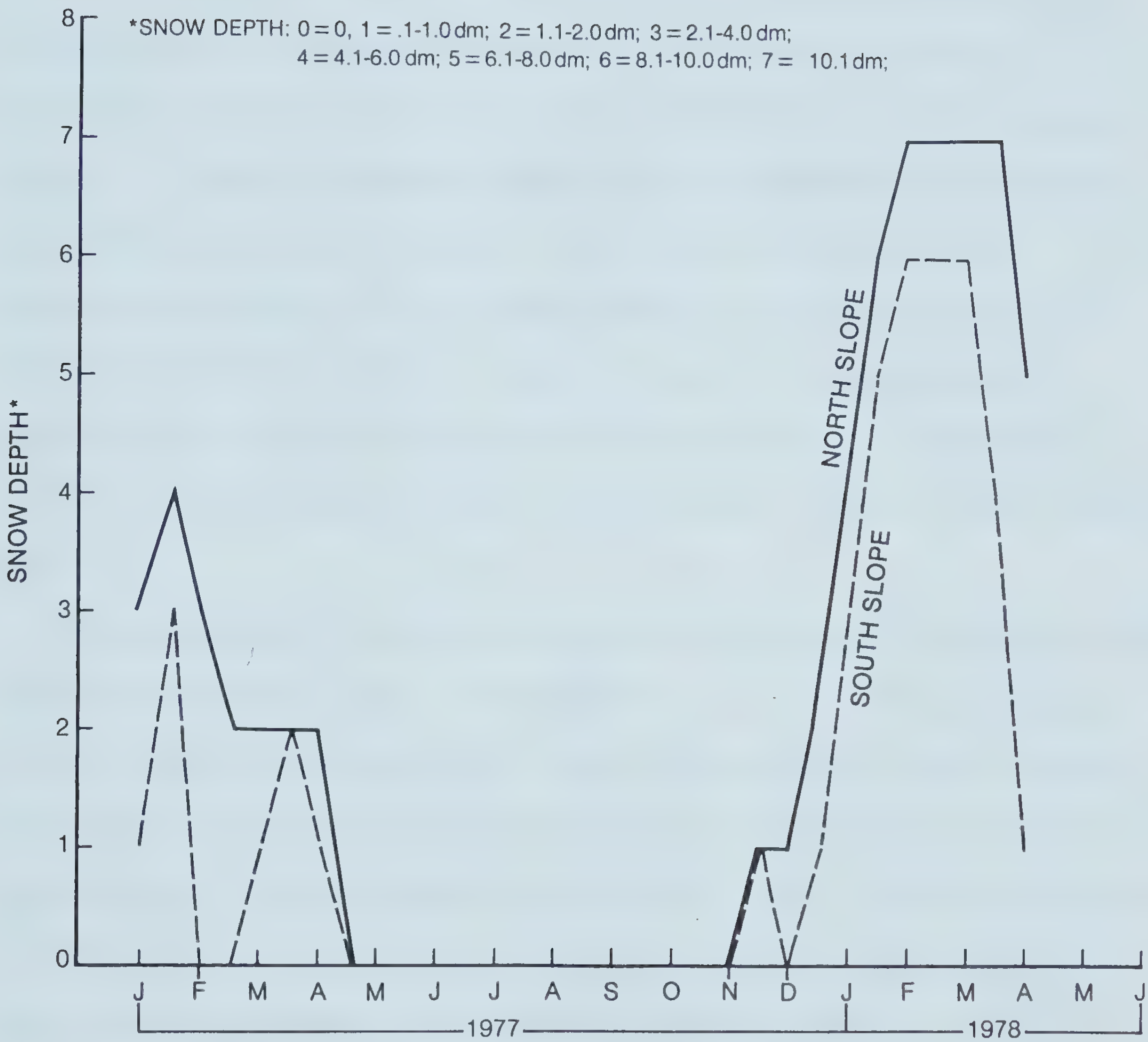

Figure 2.3 Snow depth at 15 day intervals on north-facing and south-facing slopes in the Bob Creek Area.

2.5 Phytogeography

A recent land classification described the Bob Creek Area as a complex of fescue grassland, parkland, and montane vegetation (Strong 1979). Looman (1969) classified the fescue grasslands of the area as a co-dominant mixture of rough fescue (*Festuca scabrella*) and Parry oatgrass (*Danthonia parryi*) at lower elevations replaced by rough fescue - timber oatgrass (*Danthonia intermedia*) at higher altitudes. Although Strong (1979) delineated fescue grassland as part of the glaciofluvial terrace complex in the southern part of the study area, the rough fescue association is not limited to this portion. It extends into all open grasslands on black chernozemic soils in the study area.

Parkland occurs as a transition between the montane and fescue grassland zones. Forested sites are dominated by aspen (*Populus tremuloides*) and willow (*Salix* spp.). Soils are luvisolic or chernozemic (Dormaar and Lutwick 1966). In appearance, the parkland is primarily open fescue grassland with groves of aspen; it dominates lowland areas and north-facing slopes up to 1550 m (Strong 1979).

Looman (1969) regarded the shrub species such as shrubby cinquefoil (*Potentilla fruticosa*), silverberry (*Elaeagnus commutata*), saskatoon (*Amelanchier alnifolia*), buckbrush (*Symphoricarpos occidentalis*) and rose (*Rosa acicularis*) as abundant or common in the fescue association, increasing under grazing. These species are often associated

with aspen forest where moisture is favourable.

Vegetation in the montane zone is a mosaic of fescue grassland and Douglas fir (*Pseudotsuga menziesii*). On the Whaleback Ridge these two communities tend to occupy south-facing and north-facing slopes, respectively. Limber pine (*Pinus flexilis*), bearberry (*Arctostaphylos uva-ursi*) and creeping juniper (*Juniperus horizontalis*) are present on ridges and sites with shallow soils. Soils may be regosolic, chernozemic, or brunizolic. A mixed association of lodgepole pine (*Pinus contorta*), Douglas fir and white spruce (*Picea glauca*) is also present. Similar associations have been identified in the Porcupine Hills to the east (Duffy 1971, Ogilvie 1971, Shouesmith 1972).

Fire-scarred trees are evident in many areas of the montane zone. The incidence of fire was high in southern Alberta before the turn of the century (Arno 1980, Kelly 1913). Fires in the 1930's affected substantial portions of timbered foothill range and their influence on wild ungulate distribution and population density is the subject of some speculation (A. Russell pers.comm.). Ungulate populations appeared to increase substantially during this decade perhaps in response to more open and available range.

3. THE RANGE RESOURCE

3.1 Introduction

Vegetation is usually described as either a series of discrete patches (stands) or as a continuum. In the first case, the community mosaic and the individual plant association or habitat type are the levels of distinction. In the second case the vegetation continuum and the floristic gradients are characterized. Animals may orient towards a discrete or a continuous feature at different times and for different reasons. However, their range use will be ultimately constrained by forage availability, a continuous feature (Hanley 1982a).

Although the forage resource has been previously described for plant associations in the Bob Creek Area, range use as it relates to the community mosaic has not. Since the research strategy required a subjective stratification of vegetation types, an analysis of the community represented by each type was necessary. This section describes the community component represented by each subjectively chosen range type.

3.2 Methods

3.2.1 General

After an initial reconnaisance, the vegetation was stratified into 6 subjectively recognized range types: grasslands, grass/conifer, low shrub, mixed deciduous forest, Douglas fir forest, and mixed forest. Colour infrared aerial photography was commissioned through the Alberta Center for Remote Sensing. Plots within each range type were then selected randomly from 1:20,000 scale enlargements using a Universal Transverse Mercator grid projection on a zoom transferscope. Plots were subsequently transferred to 1:20,000 black and white infrared photographs carried in the field.

3.2.2 Field Methods

Moss (1959) and Budd and Best (1969) were the authorities used for plant identification. Herbaceous vegetation was measured with a 19 mm diameter rated microplot (percent basal area and frequency were recorded) (Morris 1973) placed systematically on 15 m long paired transects. Sampling intensity was 400 microplots per transect. All vegetation, litter, bare soil, and stone was recorded as a percentage of the total area covered by the microplot.

Shrubby vegetation was sampled by the point-centre-quarter method (Mueller-Dombois and Ellenberg

1974). Sample points were placed at 5 m intervals on 25 m long paired transects; in each quarter of the point the distance to, and the height of, the nearest shrub was measured.

Forest overstory was sampled at 20 points randomly selected from an 8 x 8 point grid overlayed on each plot. Points on the grid were spaced at 3.75 m intervals (625 m^2 plot). Bitterlich's variable radius method of counting trees through a wedge prism (Mueller-Dombois and Ellenberg 1974) was used at each of the 20 selected points. Two counts were made, one for trees less than 2 m high (regeneration) and one for trees above 2 m high (mature). In addition, the total number of trees were counted in a 7.5 m diameter circular plot around each of the 20 points. Crown density over the plot was estimated on a scale of 1 to 10 from aerial photographs.

Standing crops and herbage disappearance were evaluated on 25 caged and uncaged .09 m^2 paired plots in the grassland range type (Pearson 1975). Sites were subjectively selected for similar composition on areas of observed animal use. (Six plot pairs were subsequently interfered with or destroyed). Material (on surviving plots) was clipped in late March, bagged, dried at 60°C for 24 hours, and weighed.

Sixty-three plots were examined in the vegetation survey. The distribution of plots within range types and among topographic conditions is reported in Appendix A. Grassland range types were the most intensively sampled of

the 6 range types. Grassland range condition is evaluated in Appendix A.

3.2.3 Analytical Methods

Data summaries for herbaceous, shrub, and forest vegetation were produced by computer file manipulations. All non-living material, litter, moss, lichen, or fungi was removed from the transect summaries, and all species with transect frequencies of less than 1% were reclassified into a general variable.

Classification analysis was necessary for transects on plots in the grassland range type because of the wide variation in plant associations included in this type. (Classification analysis of the forest and shrub range types resulted in no change to the original forest and shrub stratifications. Thus, analysis of these latter range types is not described.) An hierarchical classification method based on an analysis of variance (Ward 1963, Everitt 1974) was selected from CLUSTAN (Wishart 1978). Data summaries of each derived classification are reported in Appendix A.

3.3 Results

3.3.1 Grassland Range Types

Within the grassland range type, sedge (*Carex* spp.) was encountered most frequently (8%) followed by Parry oatgrass(7%), Idaho fescue (*Festuca idahoensis*) (5%), rough fescue (4%), and june grass (*Koeleria cristata*) (3%). All other species had frequencies of less than 2%, and most less than 0.5%. In addition, litter had a mean frequency of 84%, little club moss 7%, and bare soil 4% over all plots.

Comparatively, Parry oatgrass had the highest basal area coverage (167 m^2/ha) followed by Idaho fescue (137 m^2/ha), rough fescue (92 m^2/ha), juniper (86 m^2/ha), pussytoes (*Antennaria* spp.) (65 m^2/ha), sedge (57 m^2/ha) and june grass (48 m^2/ha). Litter had a mean cover of 7,403 m^2/ha, little club moss 590 m^2/ha, and bare soil 344 m^2/ha.

Standing crops varied from 372 kg/ha to 3,568 kg/ha, and averaged 1,484 kg/ha.

The following discussion briefly outlines the differences within the grasslands.

3.3.1.1 Sedge Lowland

Comprising roughly 5% of the grassland on the study area this range type occurred in poorly-drained lowland sites. Dominated by tufted hairgrass (*Deschampsia caespitosa*) and sedge, it appears to be a variant of the tufted hairgrass meadows recognized by other authorities in

the northwestern United States. Mueggler and Stewart (1981) indicate this range type to be one of the most productive in western Montana, and although production was not measured in this investigation, ground cover and height of the vegetation certainly exceeded that of the other range types. Vegetation adjacent to this type included dwarf birch (*Betula glandulosa*) and willow.

3.3.1.2 Tame Pasture

Because of topographical limitations, less than 1% of the study area was seeded to tame pasture. Smooth brome (*Bromus inermis*) was dominant, and Kentucky bluegrass (*Poa pratense*), timothy (*Phleum pratensis*) and a variety of wheatgrasses (*Agropyron* spp.) were common. No legumes were encountered.

3.3.1.3 Fescue Grassland

Five classifications could be broadly described as fescue grassland. Three of these were considered to be phases of the fescue association: a Parry oatgrass phase, a timber oatgrass phase, and a western wheatgrass phase. The other two types showed evidence of the effect of grazing fescue grasslands: a Parry oatgrass and a western wheatgrass disclimax.

Grass cover in the phases was dominated by rough fescue and Idaho fescue. Other ubiquitous species included sedge, Parry oatgrass, june grass, western porcupine grass (*Stipa spartea* var. *curtesita*), bearded wheatgrass (*Agropyron*

subsecundum) and northern wheatgrass (*A. dasystachyum*). Common forbs included northern bedstraw (*Galium boreale*), yarrow (*Achillea millefòlium*), fleabane (*Erigeron* spp.), locoweed (*Oxytropis* spp.), alum root (*Heuchera* spp.), pussytoes and pasture sage (*Artemisia frigida*). Shrub species common to this group included rose, buckbrush, shrubby cinquefoil and, on dry sites, juniper and bearberry.

The Parry oatgrass phase occurred on well-drained, moderate slope positions. It was found at altitudes from 1430 m to 1610 m on east, west, or south-facing aspects. Parry oatgrass provided the highest mean frequency followed by sedge, rough fescue, Idaho fescue, Richardson needle grass (*Stipa richardsonii*), june grass, and pasture sage. High standing crops were recorded in these plots because of the very high proportions of standing dead material.

The Timber oatgrass phase occurred on south-facing, steep, upper slopes and ridgecrests at higher altitudes in the study area (averaging 1600 m). Pussytoes were more frequent in this phase than in other phases. Other species included Idaho fescue, sedge, rough fescue, timber oatgrass, northern bedstraw, and other forbs.

The Western wheatgrass phase also occurred on south-facing upper slopes and ridgecrests, but at altitudes varying from 1460 m to 1585 m. The presence of western wheatgrass appears to be diagnostic for this variant, although other species were more frequent. A decidedly bluish hue was given to these areas because, besides sedge,

the vegetation included species such as Idaho fescue, june grass, Sandberg bluegrass (*Poa secunda*), northern wheatgrass, showy locoweed (*Oxytropis splendens*), and moss campion (*Silene acaulis*).

The Parry oatgrass disclimax was characterized by high frequencies of sedge, Parry oatgrass, june grass, and Idaho fescue; rough fescue was rarely encountered.

The Western wheatgrass disclimax was characterized by the presence of non-native grasses and forbs. Dandelion (*Taraxacum officinale*), red clover (*Trifolium pratense*), timothy and Kentucky bluegrass had invaded or escaped from cultivation on these sites. The frequency of species such as june grass, western wheatgrass, dandelion, and pussytoes implicates grazing as the dominant successional force. This disclimax was most prevalent in areas with little or no slope at lower altitudes (1430 m). Standing crops were the lowest recorded.

3.3.2 Low Shrub Range Types

Where shrubs were encountered in open grassland they were divided into one of two sub-types: willow, or rose.

The Willow sub-type varied considerably according to the dominance of three shrubs: willow, birch, and shrubby cinquefoil. This sub-type occupied lowland sites, with little or no slope.

The Rose sub-type was also quite variable. Rose or silverberry were dominant on different sites, and

chokecherry (*Prunus virginiana*) and gooseberry (*Ribes* spp.) were also present. The rose sub-type was found mostly on gentle, south-facing, lower slopes.

3.3.3 Mixed Deciduous Forest

The mixed deciduous forest was dominated by aspen poplar and associated shrub species: saskatoon, rose, buckbrush, shrubby cinquefoil, and willow. Spruce was present in several plots. Mixed deciduous forest was found at all altitudes, slopes, and aspects on the study area.

3.3.4 Douglas Fir Forest

Douglas fir forest was found above altitudes of 1490 m, on moderate to steep, north-facing slopes. Regenerating spruce was found on several sites, and one contained mature lodgepole pine and aspen. Few grasses or shrubs were present in the understory.

3.3.5 Grassland/Conifer Range Type

One of the features on the Whaleback Ridge was an open Limber pine/Douglas fir community on steep, upper slopes and ridgecrests. Tree densities were much lower than in the other forest types. Soils were shallow, and rock outcrops were frequent on sites occupied by this type. The understory was primarily fescue grassland.

3.3.6 Mixed Forest

Dense mixed stands of lodgepole pine, spruce, and Douglas fir were found throughout the study area on north-facing slopes. The forest overstory was very dense. There was little undergrowth on the sites investigated, but ryegrass (*Elymus innovatus*), buffalo-berry (*Shepherdia canadensis*), and willow were common. Deadfall was abundant on most plots.

3.4 Discussion

The divisions of the grassland range type were consistent with the classifications of several other authorities (Moss and Campbell 1947, Mueggler and Stewart 1980). Additionally, densities and dominance in the forest and shrub range types were comparable to those found in the Porcupine Hills (Duffy 1971, Ogilvie 1971, Shouesmith 1972). This allowed several inferences on range condition and the effects of use (Appendix A), and gave an understanding of the variation in discrete range types.

4. RESOURCE USE

4.1 Introduction

Resource use by ungulates can be measured in several ways. In studies aimed at describing competition, the techniques usually concentrate on the forage resource: proof of competitive interactions is contingent on finding those forages, utilized by both species, in limited supply (Cole 1958). But the management of ungulates requires more information than a description of forage competition.

> "In particular, a better understanding of habitat requirements in relation to wild ungulate behaviour is imperative to wise management decisions." (Scotter 1980, p. 24)

The purpose of this section is to describe the distributions, activities and diets of elk, mule deer, and cattle in relation to temporal, spatial, range and forage resources on the Bob Creek Area.

4.2 Methods

4.2.1 Field Methods

4.2.1.1 Animal Observations

The distribution of animals was systematically recorded by travelling a daily combination of predetermined routes

and random transects. All observations were located in the field, on 1:20,000 scale black and white aerial photographs. The locations were later converted into Universal Transverse Mercator grid coordinates and plotted.

Species, sex, age class and activity (foraging, bedded, travelling, other) were recorded for each animal observation. The range type and topographic situation (slope, aspect, and altitude) were described, and distances to known features in the area (water, salt, roads, snow and shrub or forest cover) were estimated.

Daily recordings of wind velocity, temperature and precipitation were made at base camp. However, environmental characteristics such as wind speed and direction, temperature, and barometric pressure may have considerable variation over the Bob Creek Area because of topographical differences; much more information than base station readings would be required to evaluate environmental selectivity in animals. Thus, only two parameters were used as an estimate of environmental selectivity: shade cover (created by clouds, vegetation or topographic conditions) as an indication of selection for cool or sheltered areas; and snow depth on south aspects as an indication of selection for areas of available forage.

In total, 804 observations of 17,158 animals were recorded. The distribution of observations among species and resource parameters is detailed in Appendix B. All percentage values in the figures and tables are derived from

the numbers of observations of each species given in Table B.2.

4.2.1.2 Fecal Group Distributions

Direct observation can be biased in favour of open range types and slopes adjacent to the observer's travel corridors. Fecal group counts were used to evaluate this bias and to provide additional data.

Fecal group counts and other indications of use which could be identified by species were recorded on 15 m diameter plots. Plots were placed at random along transects subjectively chosen for their proportional cover of forest and grassland vegetation (Franklin et al. 1970).

On each plot, the range type, topographic situation, and distances to known features were recorded. Soil condition was evaluated in terms of the incidence of trampling damage to plants, plant pedistalling, erosion hazards and soil movement (on a scale of none, common, widespread, severe).

During the investigation, 3,111 fecal groups were counted on 208 field plots. The distribution of fecal groups and field plots is detailed in Appendix B.

4.2.1.3 Diets

The analysis of plant fragments in feces can provide qualitative information on the relative components of herbivore diets (Anthony and Smith 1972, Vavra *et al.* 1978). There is some question concerning the technique's value as a

quantitative measure of the plant material eaten because of the likelihood of differential digestion, the variation inherent in sample preparation, and the probability of misidentification of plant fragments (Smith and Shandruk 1979, Vavra and Holechek 1980). Probably, the results of fecal fragment analysis are best used as rank order or presence/absence data.

The methods of Hansen and Clark (1977) were followed for the collection and analysis of fecal material. Collection sites were superimposed on the previously selected grassland composition plots, and were without bias for the animal species present. Samples of approximately 2 g each were collected from 50 fecal groups for each ungulate species present in the plot. These samples were composed into one sample for each species at that location.

In total, 36 composite samples were collected (Appendix B). Samples were ground in a Wiley mill through a 1 mm screen after drying at 100°C for 24 hours. One hundred microscope fields were examined per composite sample. Fecal material and individual samples of all plant species encountered during the vegetation survey of the Bob Creek Area were forwarded to the Composition Analysis Laboratory at Colorado State University for technical analysis.

4.2.2 Statistical Analysis

4.2.2.1 Distributions

Data summaries and frequency tables were used to assess the distribution of animal observations and fecal group counts. Daily summaries were related to the position of the sun in the solar arc (east, southeast, south, southwest, west) corresponding to dawn, mid-morning, noon, afternoon, and dusk. Seasonal observations were pooled into spring (April, May, June), summer (July, August, September), fall (October, November, December) and winter (January, February, March).

Observation biases and centres of animal distribution were evaluated by dividing the study area into square planar units (cells) 25 ha (500 m x 500 m) in size. The geographic centre of the study area (in NW 1/4 of section 8, Township 11, Range 2, West of the 5th Meridian) was used as a reference point. Exactly 50% of the 25 ha cells occurred north of an east/west axis running through this point, and 50% occurred west of a north/south axis. A circle, with a 4.3 km radius from the centre of the study area, covered 5,810 ha or slightly more than 50% of the total study area.

4.2.2.2 Diets

The percentage composition of plant material in ungulate feces was ranked and the ranked sets compared to determine if each sample was significantly different from the other samples (Kruskall-Wallis rank order statistic,

P=.05) (Conover 1980). The comparison tested the truth of the statement: all composite samples for one ungulate species are identical. Because each composite sample was collected in a separate location, acceptance of the statement would indicate that the diet of that ungulate was similar throughout the Bob Creek Area.

4.2.2.3 Activities

Comparisons between a species' activity and its distribution along temporal, spatial, and environmental gradients were made by multivariate nominal scale analysis (MNA) (Andrews and Messenger 1973).

The coefficients of response produced by an MNA model, indicate whether the observed response to an independent variable is proportionately more or less than expected. The use and limitations of these and other MNA statistics for ecological studies involving ungulates have been discussed by Hudson (1977). Tables of animal response to ecological features in the Bob Creek Area are included in Appendix C.

4.3 Results

4.3.1 Seasonal Use of the Bob Creek Area

Ungulate distributions in the Bob Creek Area reflected traditional, seasonal patterns of movement.

4.3.1.1 Elk

Regional helicopter surveys by the Alberta Fish and Wildlife Division reported nearly 700 elk on the Bob Creek Area in March 1977 and 1978. This is a fairly accurate estimate of the maximum number of elk that may migrate to the area each winter. However, the actual use of the area varies seasonally, as indicated by the average size of herds observed in 1977 and 1978 (Figure 4.1). The largest bands were observed in mid-winter, during the fall rut, and late fall migration. Only 2 observations of elk were made in the summer of 1977 after calving (Appendix B).

Group sizes fell at the opening of the hunting season. No poaching was observed prior to the hunting season although one week earlier the number of small aircraft and observation parties increased substantially.

Peak aggregations were observed in late winter, just prior to spring migration. Band sizes of over 50 animals were observed 3 times in February and 20 times in March, 1977. The largest band, 263 head, was seen in the last week of March. One week later the largest band was 59 head, the maximum for April observations. During 1978, the largest herd, comprising 220 head, was seen on 25 February.

4.3.1.2 Mule Deer

Fish and Wildlife Division surveys reported less than 35 head of mule deer in March 1977, and about 200 head in March 1978. The latter figure is probably the better

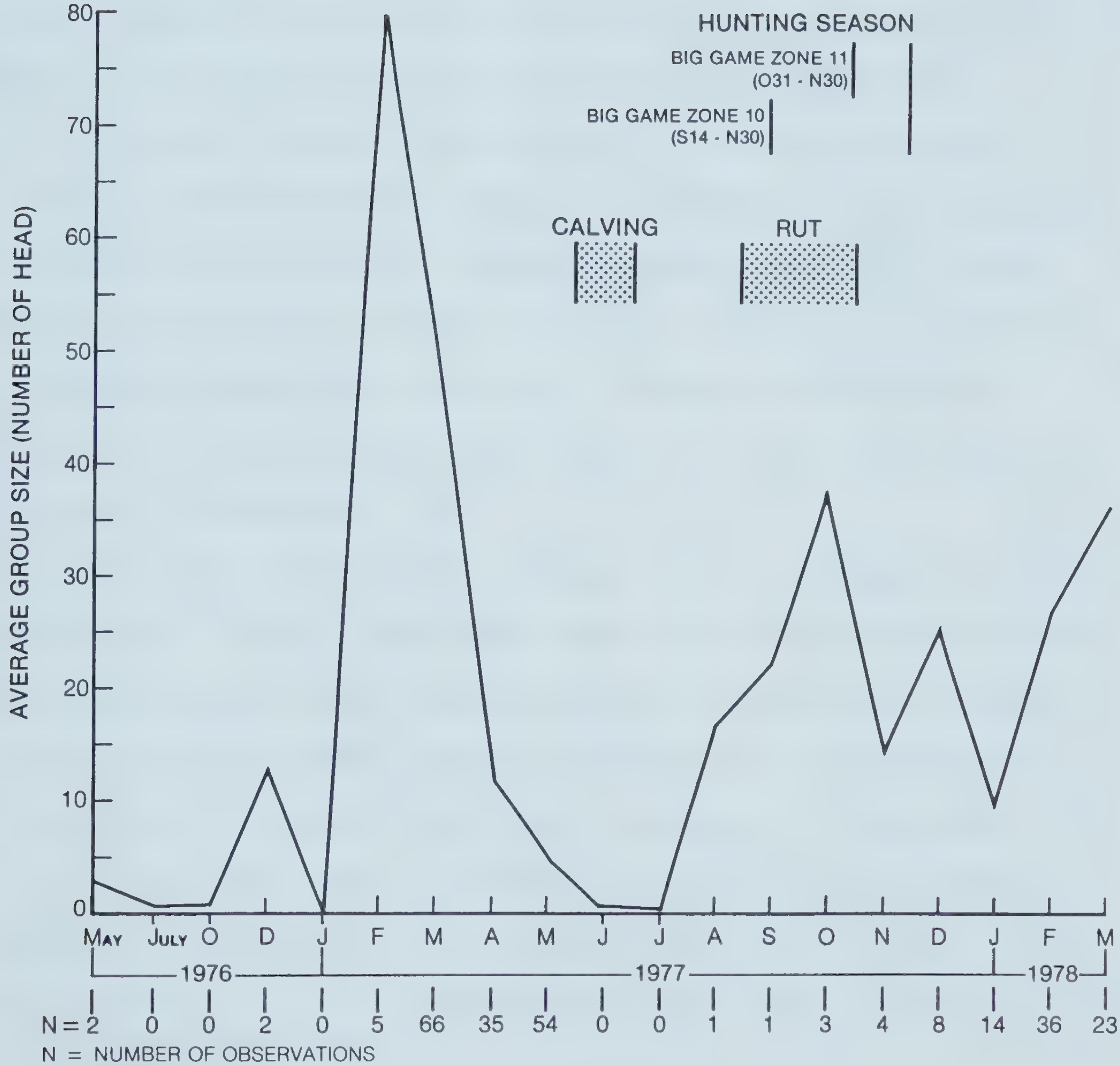

Figure 4.1 Average group size of elk in relation to month of observation, reproductive activity, and hunting seasons.

estimate of the mule deer population normally wintering on the Bob Creek Area.

The largest mule deer bands were observed in mid-winter and prior to the fall rut (Figure 4.2). Solitary animals were observed for the most part during the fawning period. Band sizes did not exceed 3 animals until September.

Mule deer became increasingly elusive through the hunting season and into the rut. Incidences of poaching were reported to authorities commencing approximately 2 weeks prior to the Zone 11 hunting season. Maximum band sizes of 12 animals observed in October, dropped to maximums of 6 animals in November. No observations of mule deer were recorded in December 1977.

In mid to late winter average band sizes peaked. During March 1977, 9 mule deer bands were observed with more than 10 animals each; the largest band had 69 animals. In April 1977 only 2 mule deer bands of more than 10 animals were observed; the largest band had 18 animals. In February 1978, 6 bands had more than 10 animals each; the largest was a group of 81 animals. During March 1978, only 4 bands were observed with counts exceeding 10 head; the largest band had 37 animals.

4.3.1.3 Cattle

Three livestock management systems are present in the Bob Creek Area. The Waldron Grazing Cooperative grazes the east flank of the Whaleback Ridge; deeded ranch lands

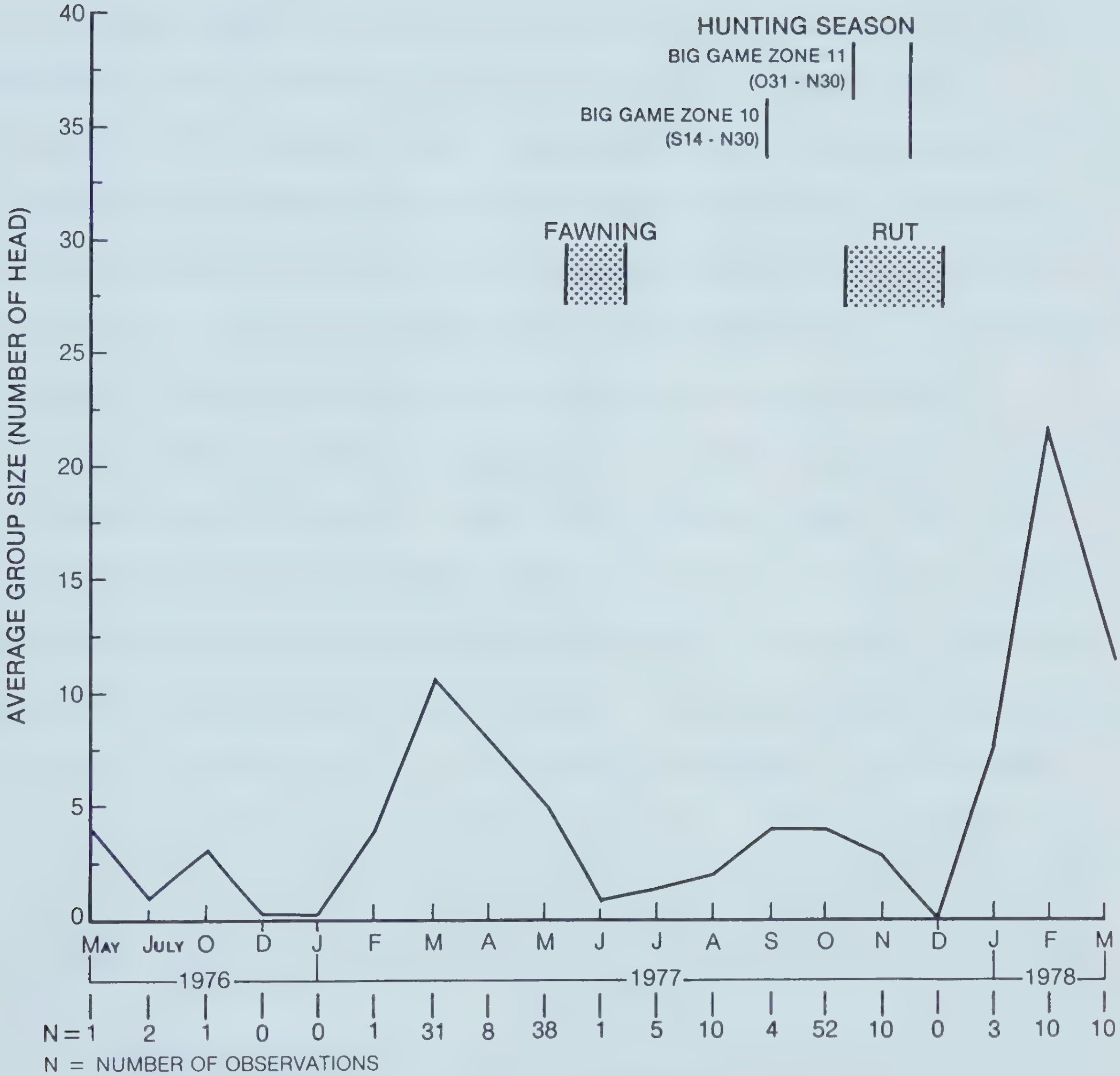

Figure 4.2 Average group size of mule deer in relation to month of observation, reproductive activity, and hunting seasons.

comprise most of the southern third of the study area; and the Bob Creek and Lower Spring Creek Forest Reserve grazing allotments are administered by the Alberta Forest Service.

During 1977, cattle grazed portions of the study area for varying periods. The southern third of the Bob Creek allotment was grazed by 228 head from 16 June to 12 November. The middle third was grazed by 513 head from 15 July to 24 November. And the northern third was grazed by 234 head from 30 June to 24 November. Stock were, for the most part, commercial bred yearlings. Mature stock included a number of longhorn steers, some over 4 years old.

Grazing of the Lower Spring allotment was broken into 7 different periods and 3 areas. The Miles Coulee area was grazed by 95 head from 15 July to 1 October when they were moved to the east side of the allotment. The east side was grazed from 15 June to 22 October: 134 head from 15 June to 15 July; 53 head from 15 July to 22 October; and 95 head from 1 October to 22 October. The west side was grazed from 18 June to 22 October: 76 head from 18 June to 15 July; and 65 head from 15 July to 22 October. All stock were yearling cattle.

Livestock operations and movements outside of the Forest Reserve were also recorded. Winter stock feeding operations and calving occurred on deeded land during March. Cattle were moved onto the Waldron range almost 1 month earlier than they were allowed into the Forest Reserve.

Average group sizes for cattle increased at the beginning and end of the grazing season (Figure 4.3) During the summer the average size of cattle aggregations fell. Herds of over 50 head were not normally encountered except on extremely hot days, days with strong winds, and on rainy days. The first 3 snowfalls (8 October, 26 October, 2 November) melted completely within 3 days. After the October snowfalls, aggregations exceeded 50 head for the most part only on windy days. After the 2 November 1977 snowfall, minimum daily temperatures remained below 0°C. Aggregations exceeded 100 head, 5 times in the week following. Fall roundups began after this period.

4.3.2 Spatial and Topographical Use

Each ungulate had a distinctive distribution over the range of topographical features in the Bob Creek Area.

4.3.2.1 Elk

Elk were observed on 28% (129 cells) of the study area. Observations were evenly divided between the east and west (48.1% west) but strongly favoured the south and central portions (69% south; 76% within 4.3 km of the study area's centre). Elk concentrated on Sailor Jack Ridge, between Beaverdam and Coyote Creeks, and on the east side of the Whaleback Ridge (Figure 4.4).

On the basis of observations, elk favoured altitudes above 1500 m, southern aspects, and gentle to moderate

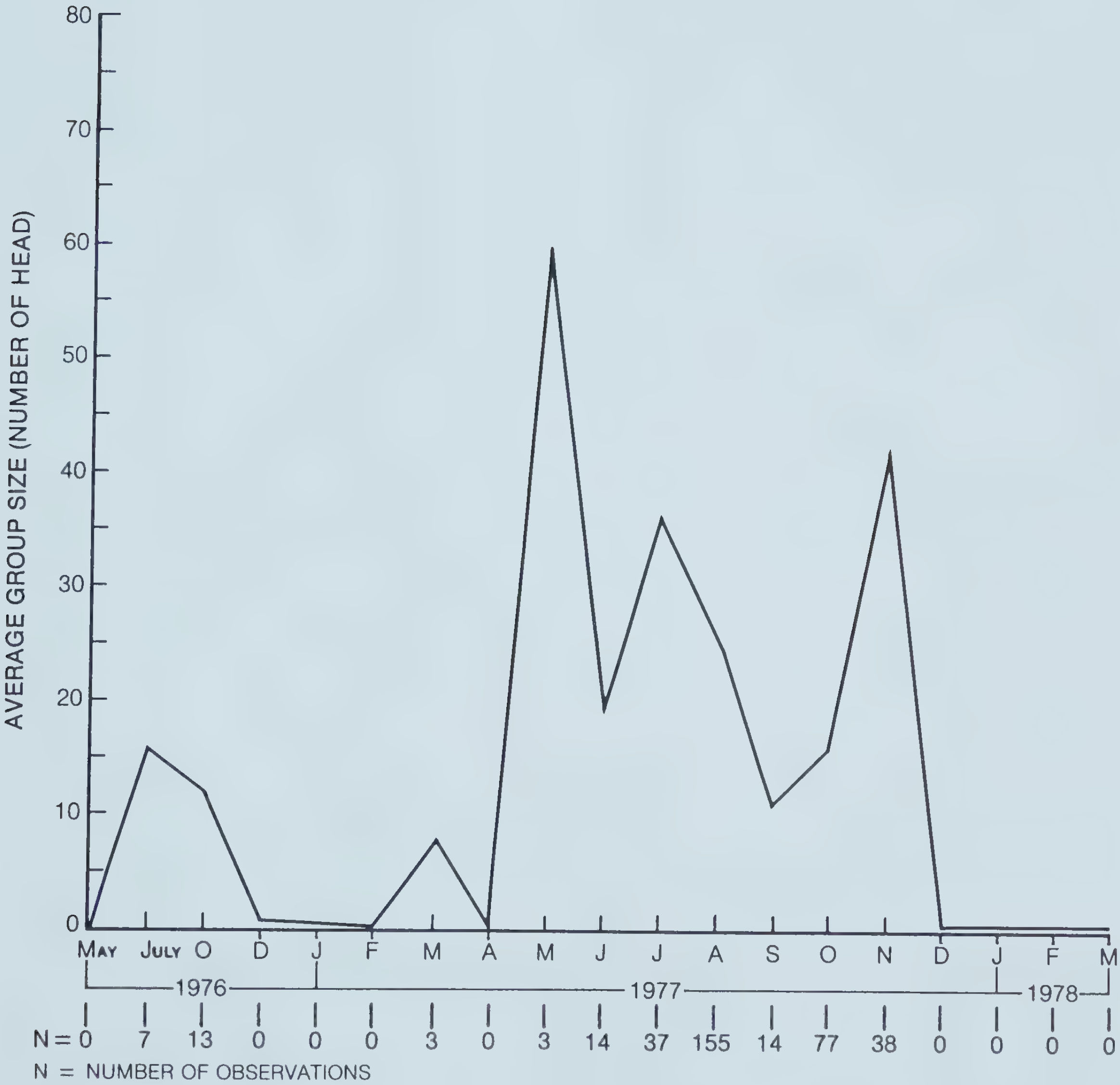

Figure 4.3 Average group size of cattle in relation to month of observation.

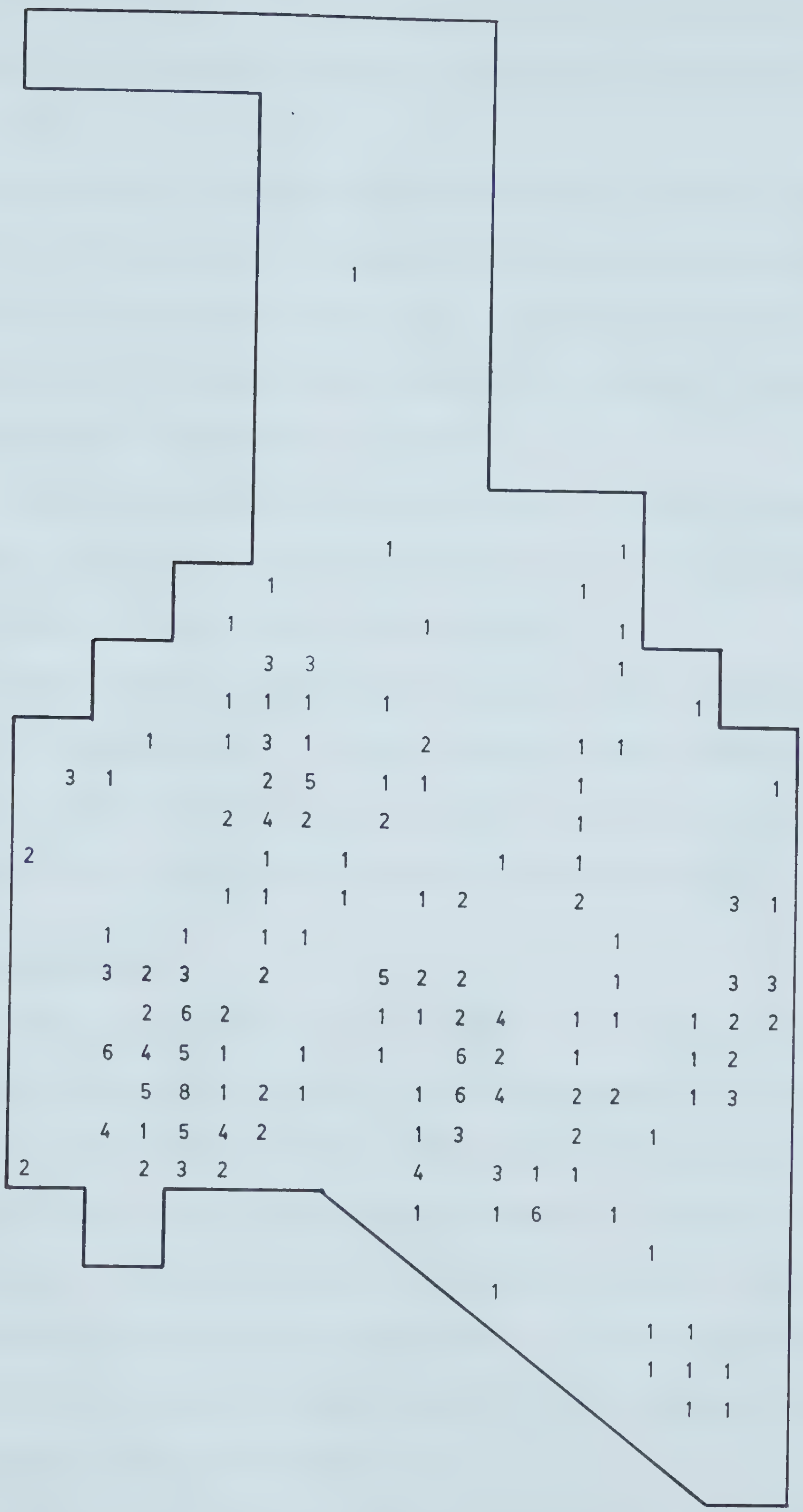

Figure 4.4 Distribution of elk in the Bob Creek Area (observations/25 ha).

slopes. Fecal groups were proportionately greater at higher elevations, on steeper slopes, and on north aspects (Appendix B).

Specifically, elk favoured elevations between 1500 m and 1600 m. (Figure 4.5). Seasonally, they selected higher elevations in the spring and fall. Diurnally, higher elevations were selected throughout the morning, peaking at noon, and lower elevations at dusk.

For the most part, elk used gentle (0-10%) slopes in all seasons and daily periods (Figure 4.6). Steep slopes were selected in the winter and spring.

Elk were usually observed on south (SE, S, SW) aspects (Table 4.1). Secondarily, their use shifted from west aspects in the winter to east aspects in the spring, and from west in the mornings to east in the evenings.

4.3.2.2 Mule Deer

Mule deer were observed on 24% (110 cells) of the study area. Observations were evenly divided between the east and west (50.0% west) but strongly favoured the south and central portions (80% south; 60% within 4.3 km of the study area's centre). Mule deer concentrated on Sailor Jack Ridge, on the southern portion of Bob Creek, on the hills between Coyote Creek and Eagle Coulee, and on the southern tip of the Whaleback Ridge (Figure 4.7).

On the basis of observations, mule deer favoured altitudes below 1500 m, gentle slopes, and southern aspects.

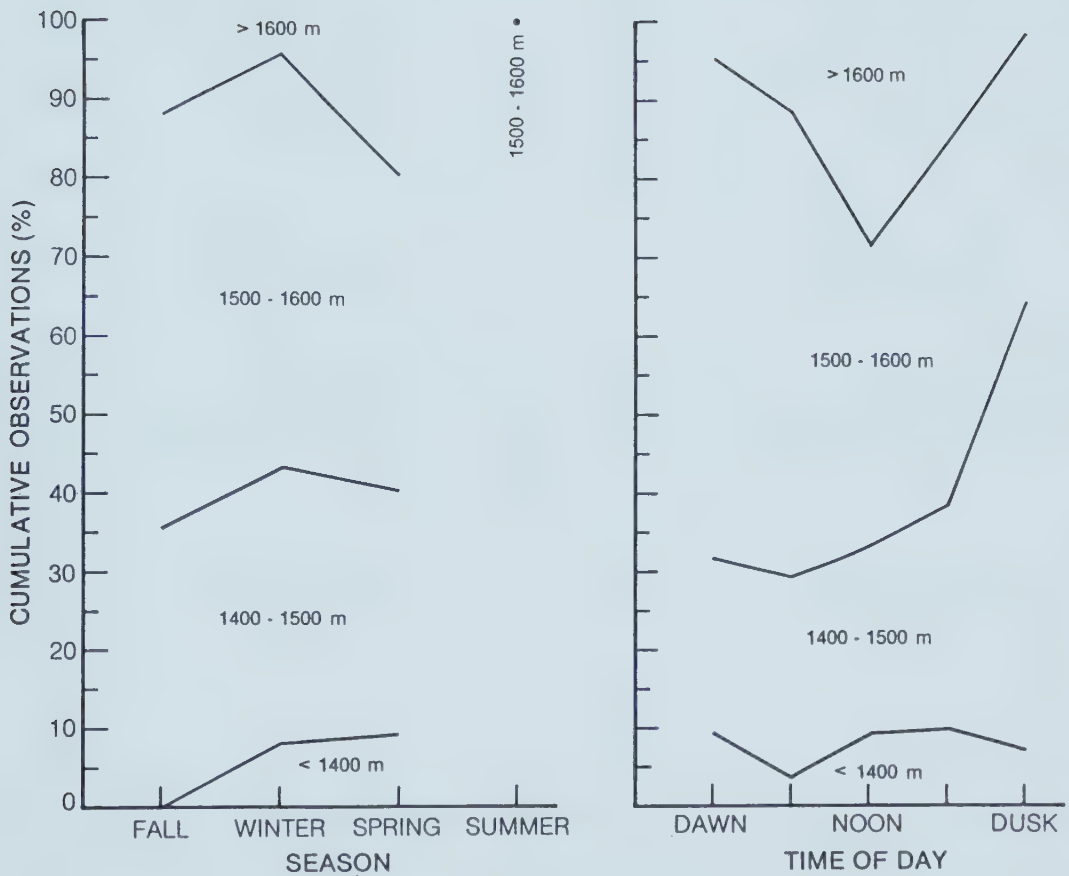

Figure 4.5 Seasonal and diurnal distribution of elk in relation to altitude.

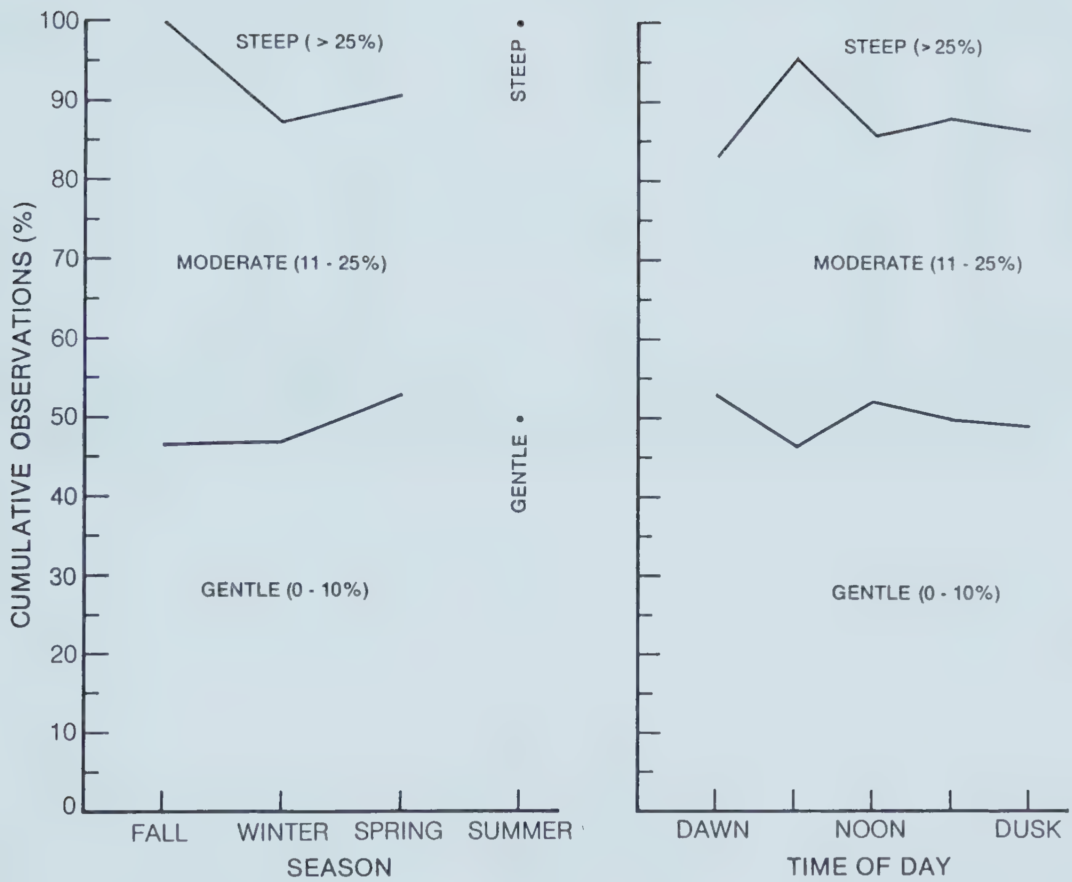

Figure 4.6 Seasonal and diurnal distribution of elk in relation to slope.

Table 4.1 Seasonal and diurnal distribution of elk in relation to aspect.

Aspect*	Total Observations								
	Season				Time-of-day				
	Spr.	Sum.	Fall	Win.	Dawn	Mid Morn.	Noon	Aft. Noon	Dusk
North	2	0	1	5	2	3	0	1	2
East	48	1	3	29	9	18	10	21	21
West	24	0	4	102	19	31	3	25	17
South	55	2	14	118	31	54	15	42	37
Nil	2	0	0	1	0	2	0	0	1

* The number of observations in the table are the sum total of observations made on each of the following aspect groups: North=NW,N,NE; East=NE,E,SE; West=NW,W,SW; South=SW,S,SE; Nil=No aspect.

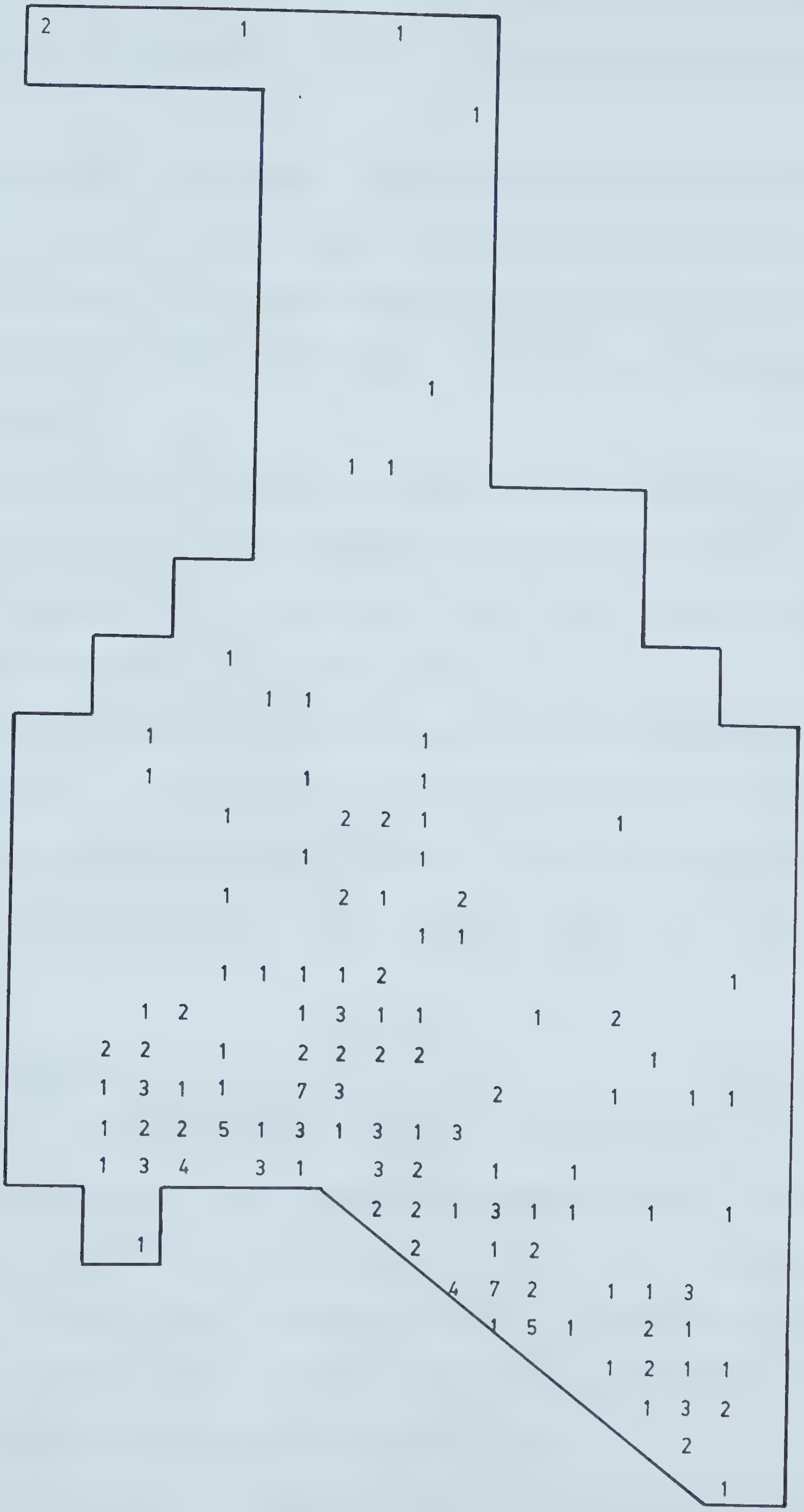

Figure 4.7 Distribution of mule deer in the Bob Creek Area (observations/25 ha).

Fecal groups were proportionately greater at higher elevations, on steeper slopes, and north aspects (Appendix B).

Seasonally, mule deer favoured higher elevations in the winter and spring, and lower elevations in the fall (Figure 4.8). Diurnally, they selected higher elevations at mid-morning and noon, and lower elevations at dawn and in the afternoon.

Mule deer used gentle slopes in the spring, summer and fall, but favoured more moderate and steep slopes in the winter (Figure 4.9). During the day they selected moderate and steep slopes at dawn and dusk.

Mule deer selected south aspects, secondarily favouring east aspects in the spring and west aspects in winter. On a daily basis they shifted from west aspects at dawn to east aspects at mid-day, and back to west aspects at dusk (Table 4.2).

4.3.2.3 Cattle

Cattle were observed on 33% (154 cells) of the study area. Observations were evenly divided between the east and west (53.0% west) but favoured the north and central portions (55.0% north; 66.4% within 4.3 km of the study area's centre). Cattle were concentrated on the Bob Creek and Beaverdam Creek areas (Figure 4.10).

On the basis of observations, cattle favoured altitudes between 1400 m and 1500 m, gentle slopes, and southern

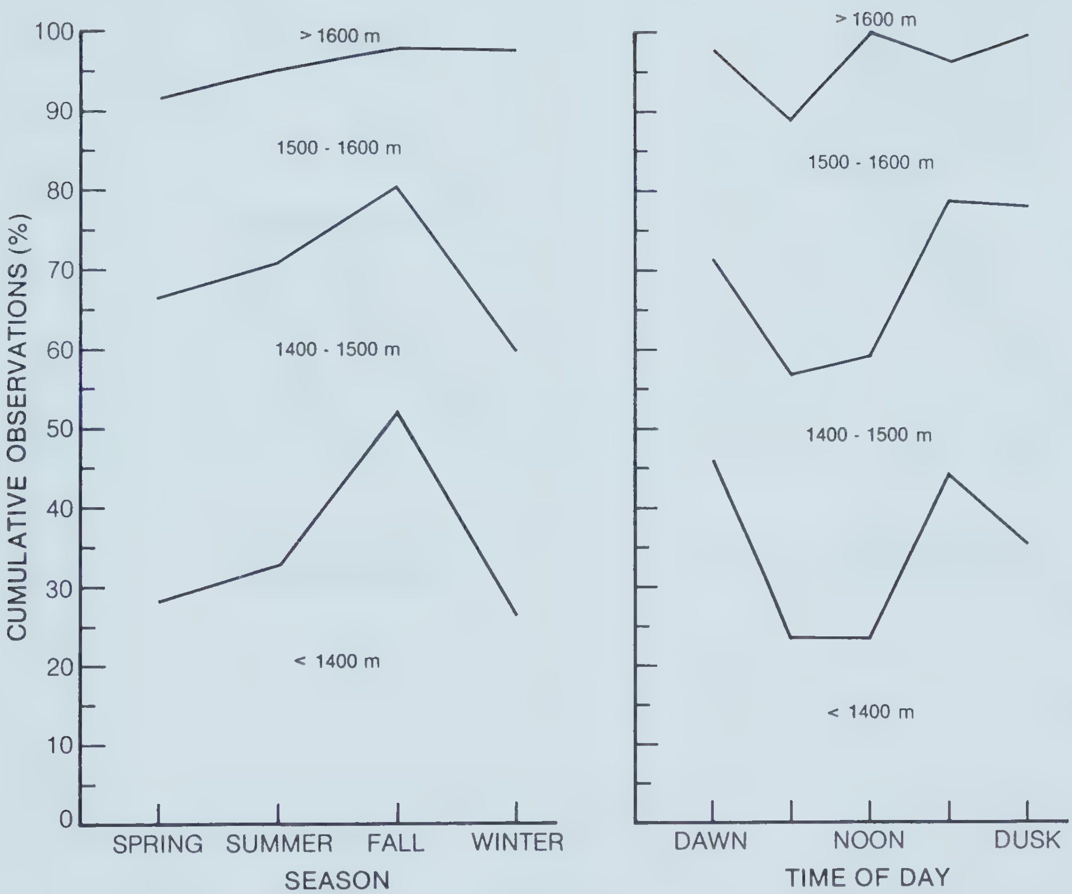

Figure 4.8 Seasonal and diurnal distribution of mule deer in relation to altitude.

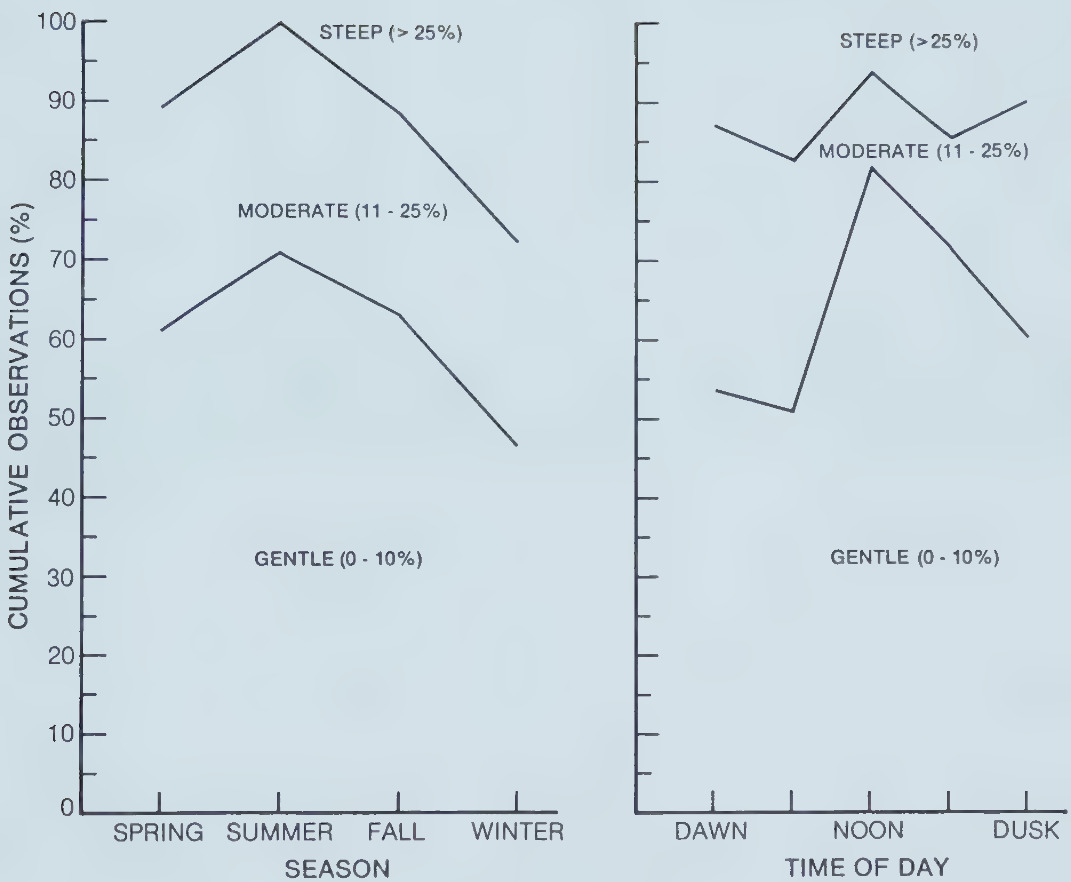

Figure 4.9 Seasonal and diurnal distribution of mule deer in relation to slope.

Table 4.2 Seasonal and diurnal distribution of mule deer in relation to aspect.

Aspect*	Total Observations								
	Season				Time-of-day				
	Spr.	Sum.	Fall	Win.	Dawn	Mid Morn.	Noon	Aft. Noon	Dusk
North	4	1	2	1	2	3	2	1	0
East	18	4	13	12	15	11	6	11	4
West	13	6	12	21	23	11	3	6	7
South	28	12	36	46	36	32	9	22	20
Nil	5	6	11	2	6	4	3	5	6

* The number of observations in the table are the sum total of observations made on each of the following aspect groups: North=NW,N,NE; East=NE,E,SE; West=NW,W,SW; South=SW,S,SE; Nil=No aspect.

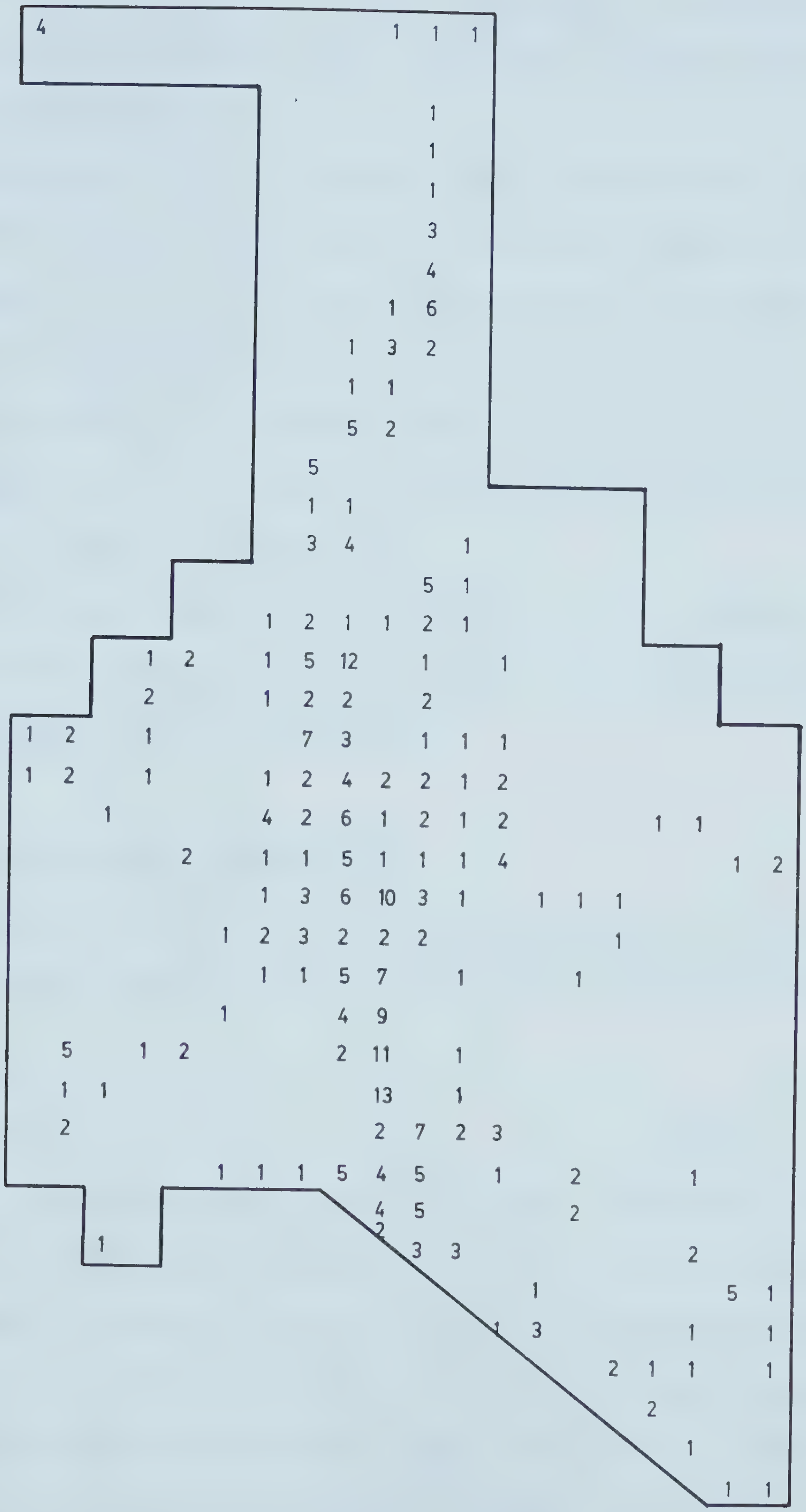

Figure 4.10 Distribution of cattle in the Bob Creek Area (observations/25 ha).

aspects or flat terrain. Fecal groups were proportionately greater at higher elevations, on steeper slopes, and north aspects (Appendix B).

Seasonally cattle selected lower elevations in the spring and higher elevations in the fall (Figure 4.11). On a daily basis, cattle favoured lower elevations at dawn and dusk, and higher elevations at mid-morning.

Cattle selected gentle slopes, more so in the spring than summer or fall. Moderate and steep slopes were favoured at dawn and dusk (Figure 4.12).

Cattle were observed primarily on south aspects, favouring west aspects secondarily in the spring and fall and on a daily basis (Table 4.3).

4.3.3 Use of Plant Communities

Ungulates exhibited a selective pattern of use when their distributions were compared with the plant community mosaic.

4.3.3.1 Elk

Elk selected grassland range types, adjacent to mixed deciduous forest, or Douglas fir forest, favouring areas within 25 m of tree or shrub cover. (In contrast, elk defecated more often in areas adjacent to mixed forest and open grassland/conifer range types and further from cover: most fecal groups were recorded between 100 m and 250 m from cover (Appendix B)). Elk favoured forested range

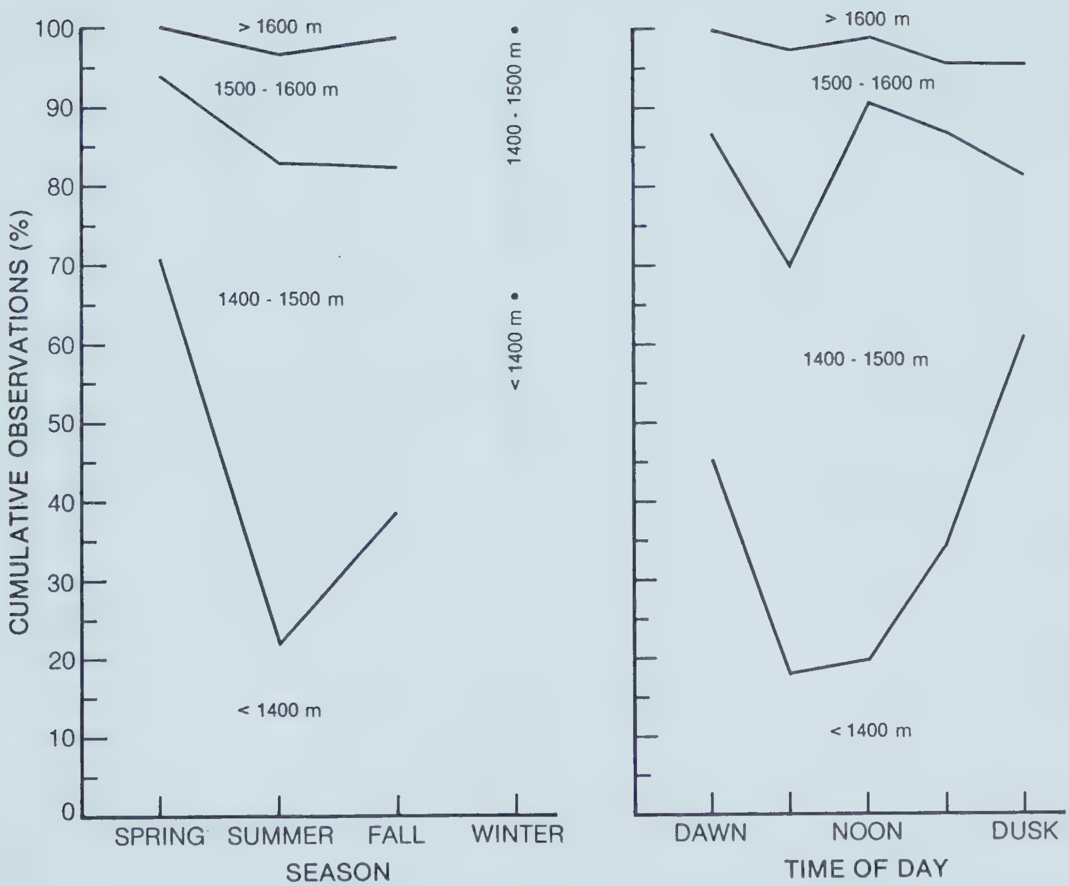

Figure 4.11 Seasonal and diurnal distribution of cattle in relation to altitude.

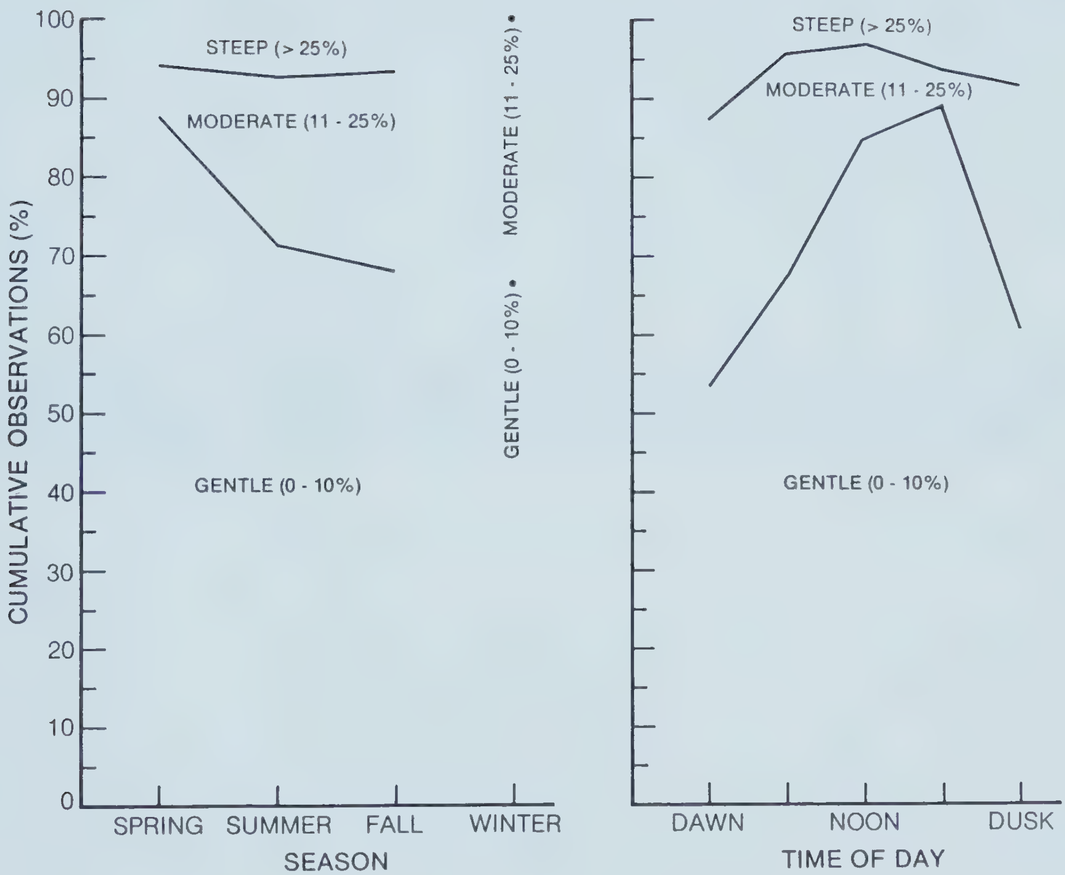

Figure 4.12 Seasonal and diurnal distribution of cattle in relation to slope.

Table 4.3 Seasonal and diurnal distribution of cattle in relation to aspect.

Aspect*	Total Observations								
	Season				Time-of-day				
	Spr.	Sum.	Fall	Win.	Dawn	Mid Morn.	Noon	Aft. Noon	Dusk
North	2	7	3	0	5	2	4	0	0
East	1	61	15	1	15	20	23	10	10
West	5	66	40	1	36	33	23	12	7
South	10	116	58	3	56	57	39	25	10
Nil	4	46	41	0	14	19	36	17	5

* The number of observations in the table are the sum total of observations made on each of the following aspect groups: North=NW,N,NE; East=NE,E,SE; West=NW,W,SW; South=SW,S,SE; Nil=No aspect.

types - Douglas fir, mixed deciduous, and grassland/conifer types - more often in the fall than in other seasons. On a daily basis elk selected forested range types primarily at noon (Figure 4.13).

4.3.3.2 Mule Deer

Mule deer selected grassland range types adjacent to mixed deciduous or grass/conifer range types, favouring areas within 25 m of tree or shrub cover (Mule deer defecated primarily in areas adjacent to grass/conifer and Douglas fir forest and between 25 m and 100 m from cover (Appendix B)).

Mule deer selected low shrub range types relatively more often in the fall and winter. They were observed in forested range types least often in winter and most often in spring (Figure 4.14).

Diurnally mule deer were observed in grassland and low shrub range types from dawn to mid-morning. They were observed in forested range types more often in the afternoon. Low shrub communities were also important in the afternoon and at dusk.

4.3.3.3 Cattle

Cattle selected grassland range types adjacent to mixed deciduous forests, favouring areas within 100 m of tree cover, and within 25 m of shrubs (Appendix B). (However, cattle defecated more in areas adjacent to grass/conifer range types and other forest types.)

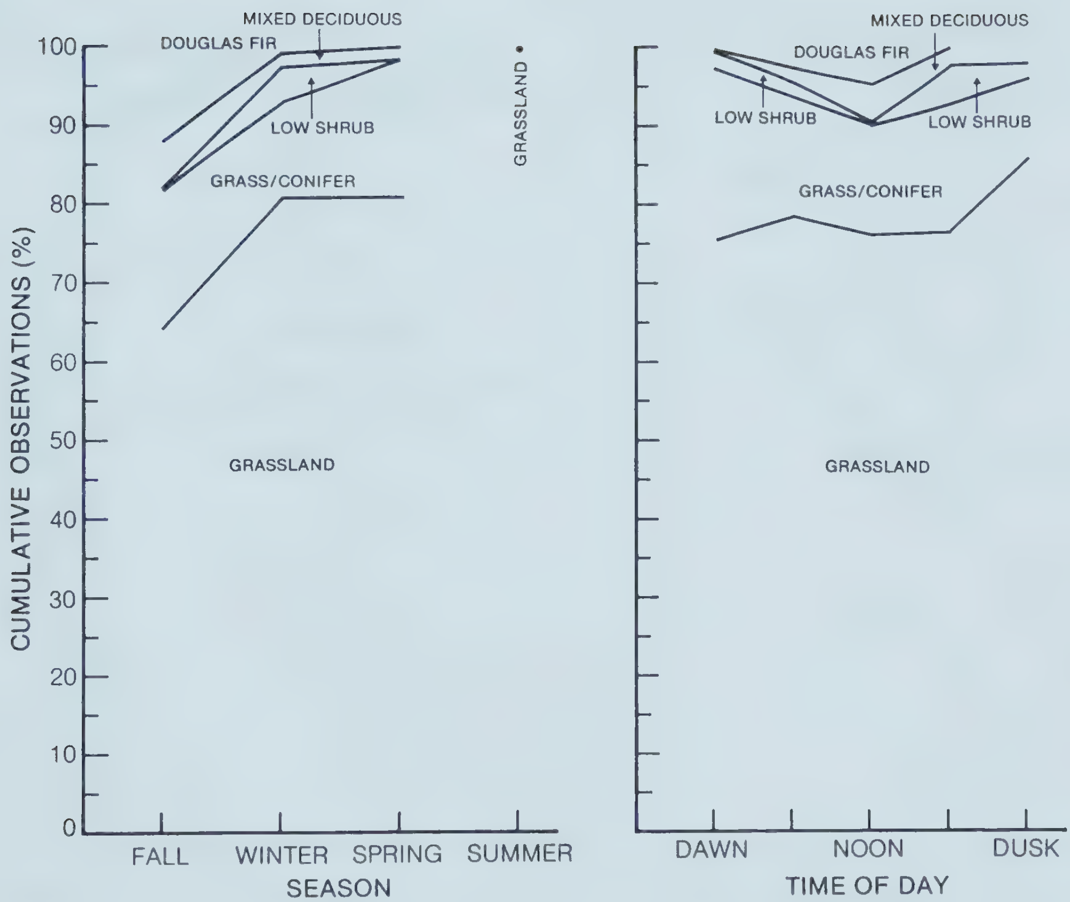

Figure 4.13 Seasonal and diurnal distribution of elk in relation to habitat.

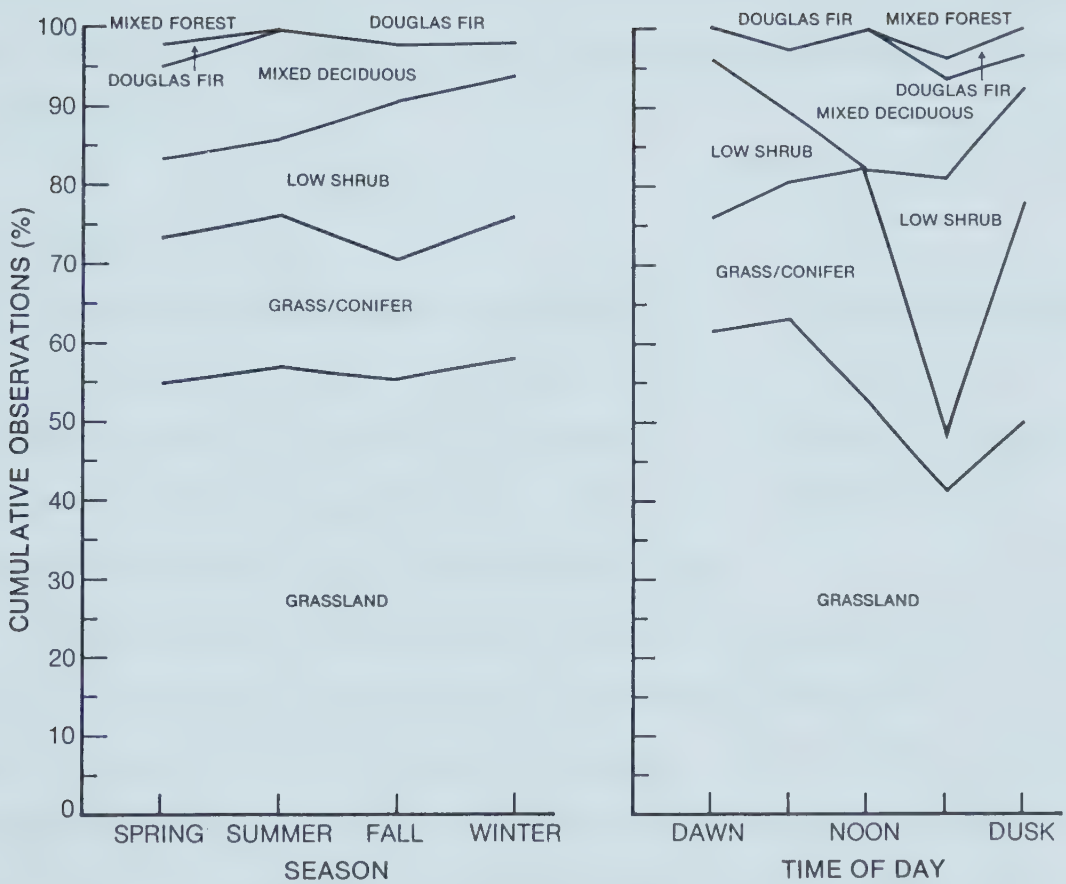

Figure 4.14 Seasonal and diurnal distribution of mule deer in relation to habitat.

Cattle were observed in grassland range, more so in the fall than in the spring (Figure 4.15). They selected low shrub, grass/conifer, and mixed forest most often in summer and mixed deciduous forest most often in spring.

Diurnally, cattle favoured grassland range types at dawn and dusk. They were observed more often in low shrub and mixed forest types at noon, and mixed deciduous forest in the afternoon.

4.3.4 Diets

Considering the wide variety of plant species available in the Bob Creek Area, ungulates selected only a few as forage. In part, this may be related to problems inherent in analyzing plant fragments that have been subjected to digestive degredation in an animal's gut.

Errors from the technical analysis included the identification of squirrel tail (*Sitanion hystrix*) as a minor component in 2 composite samples of elk feces and 2 composite samples of cattle feces. This species was not observed in the vegetation survey and would probably be of very minor occurrence if present (Budd and Best 1969); it is included in the 'Other' grass category. A fragment identified as *Oryzopsis hymenoides* was reported in one mule deer composite sample, a species not observed during the range survey; it was also included in the 'Other' grass category. The forb component was not well represented, which may reflect any combination of dietary selectivity, plant

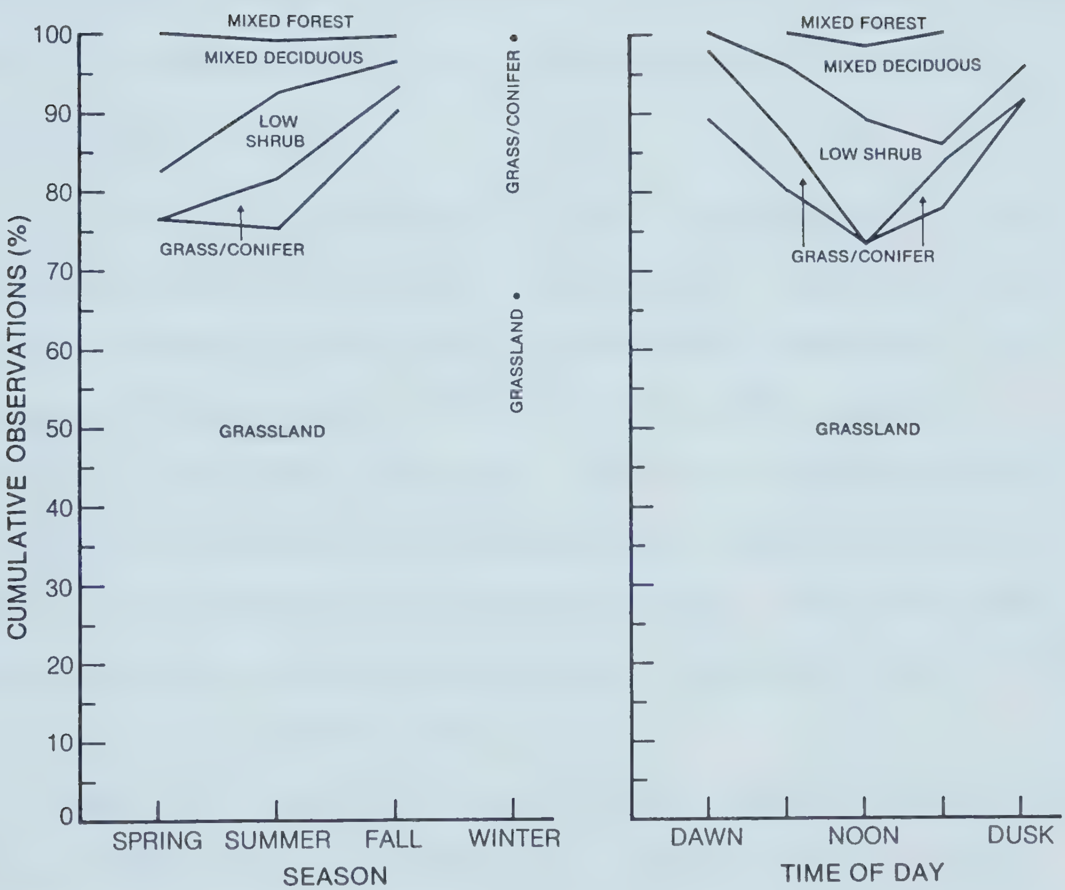

Figure 4.15 Seasonal and diurnal distribution of cattle in relation to habitat.

fragment degredation and digestion, or technical errors. Classifications of *'Boraginaceae'* and *'Compositae'* are so broad that they effectively function as 'Other' forb categories. One technical error was present in the browse component: a fragment identified as *Quercus* was recorded in one composite sample of mule deer feces. This genus is not listed by Moss (1959) as an indigenous Alberta taxon.

4.3.4.1 Elk

The diets of wintering elk were composed of a wide variety of species. However, the grasses, especially the fescues (*Festuca*) were the most prevalent material. On average, fescues made up 89.3% of the grass material identified. The most important forb was sage (*Artemisia*), and browse, Douglas fir (*Pseudotsuga*). Forbs were least often identified perhaps because they are less available, less palatable, or less identifiable after passing through elk digestive systems (Table 4.4).

Some local selection was evident, but not significant. For example, bluegrass (*Poa* spp.) appears to be locally important in the Bob Creek and Whaleback Ridge samples; brome (*Bromus*) is more prevalent in the Spring Creek samples; wheatgrass (*Agropyron*) is found mostly in samples from the Whaleback Ridge.

Table 4.4 Average composition (%) of plants in elk winter diets from 3 locales in the Bob Creek Area.

Plant Type	Spring Creek (5)	Bob Creek (10)	Whaleback Ridge (3)	Avge. (18)
Grass/Sedge				
Agropyron	.15	.07	.65	.19
Bouteloua	.06	.29	0.0	.18
Bromus	.33	.05	.08	.13
Danthonia	4.01	5.74	3.12	4.82
Elymus	0.0	.03	.19	.05
Festuca	89.54	82.84	85.60	85.16
Koeleria	.22	.37	.08	.28
Poa	.69	.91	1.10	.88
Stipa	.57	1.33	.67	1.00
Carex	1.60	3.05	2.70	2.59
Other	.06	.06	0.0	.05
Total	97.23	94.74	94.19	95.33
Forbs				
Artemisia	.42	.19	.11	.24
Compositae	.06	.03	0.0	.03
Lupinus	.06	.12	0.0	.08
Total	.54	.34	.11	.35
Browse				
Elaeagnus	.06	0.0	0.0	.02
Juniperus	0.0	.62	.35	.40
Picea	0.0	.09	.46	.13
Pseudotsuga	2.16	4.16	4.88	3.72
Rubus	0.0	.03	0.0	.02
Salix	0.0	.03	0.0	.02
Total	2.22	4.93	5.69	4.31

(_)=number of composite samples in the locale

4.3.4.2 Mule Deer

Browse was the principal forage source for mule deer wintering in the Bob Creek Area, and primarily, Douglas fir (*Pseudotsuga*) (Table 4.5). Juniper (*Juniperus*) and silverberry (*Elaeagnus*) were important components in the Bob Creek and Whaleback Ridge locales. The forb component was the least prevalent, apparently confined to species of sage.

Some local but not significant differences occur, sedge being utilized more along Bob Creek, and wheatgrass, bluegrass and needlegrass on the Whaleback Ridge. The fescues were the most ubiquitous grasses in the diet.

4.3.4.3 Cattle

Grasses and sedge made up an average of 98.6% of the material in summer cattle diets. Fescues (*Festuca*) averaged 88.3% of the grass material (Table 4.6). The most important forb was sage, a component contributed only from the southern third of Bob Creek. Forbs, more than any other group, may be locally selected; no single forb was present in all samples.

Douglas fir was the most important browse component and it was selected only in Bob Creek locales. Wheatgrass, grama grass, and bluegrass were present to greater degrees in samples from the southern third of the Bob Creek. Rushes (*Juncus*) were present in samples from the middle and northern thirds of Bob Creek, and from the Whaleback Ridge. A high proportion of sedge was present in the northern Bob

Table 4.5 Average composition (%) of plants in mule deer winter diets from 3 locales in the Bob Creek Area.

Plant Type	Spring Creek (2)	Bob Creek (1)	Whaleback Ridge (3)	Avge. (6)
Grass/Sedge				
Agropyron	0.0	0.0	.04	.02
Danthonia	.07	.32	.48	.31
Festuca	3.53	3.68	1.46	2.52
Poa	0.0	0.0	.04	.02
Stipa	0.0	0.0	.04	.02
Carex	0.0	.32	0.0	.05
Other	0.0	0.0	.07	.03
Total	3.59	4.32	2.13	2.97
Forbs				
Artemisia	0.0	.32	.09	.10
Other	0.0	0.0	.13	.06
Total	0.0	.32	.22	.16
Browse				
Elaeagnus	.07	8.71	0.0	1.47
Juniperus	0.0	12.20	6.43	5.25
Picea	0.0	1.62	1.93	1.24
Pseudotsuga	96.21	72.83	89.20	88.81
Salix	0.0	0.0	.09	.05
Other	.13	0.0	0.0	.05
Total	96.41	95.36	97.65	96.87

(_)=number of composite samples in the locale

Creek samples as well.

4.3.5 Environmental Selection

Ungulates actively select some of the environmental conditions which surround them. Examples include the selection of areas with greater or lesser shade cover, snow depth, and distances to features such as water and salt. The distribution of ungulates in the Bob Creek Area reflect these influences.

4.3.5.1 Elk

Elk were usually observed in either unshaded or totally shaded conditions (Table 4.7). Not unexpectedly, shaded elk were observed more often on north and west aspects and in forested range types.

As snow depth increased, elk increasingly favoured moderate (11-25%) slopes, more westerly aspects and the grass/conifer range type. Whenever snow depths exceeded 6 dm, elk were usually observed on gentle and moderate, southwest, grassy slopes.

Elk were not observed using cattle salting stations although elk tracks and dung were often present around them. They also watered at a few small, ice-free springs. However, the contribution of these factors to elk range use could not be discerned because of the difficulty of locating the water or salt source nearest to an animal observation.

Table 4.6 Average composition (%) of plants in cattle summer diets from 5 locales in the Bob Creek Area.

Plant Type	Spring Creek	Bob Creek			Whaleback Ridge	Avge.
		North	Middle	South		
	(1)	(1)	(6)	(3)	(3)	(12)
Grass/Sedge						
Agropyron	0.0	0.0	0.0	.23	0.0	.06
Bouteloua	0.0	0.0	0.0	.38	0.0	.10
Bromus	.45	.48	.27	.08	0.0	.23
Danthonia	8.75	1.43	4.08	5.35	3.84	4.55
Festuca	86.70	80.67	89.50	84.99	92.39	87.64
Koeleria	0.0	1.91	.15	.67	.48	.44
Poa	0.0	0.0	.09	.87	.24	.28
Stipa	0.0	1.43	.87	1.51	0.0	.93
Carex	3.20	11.69	3.26	4.71	2.33	4.24
Juncus	0.0	1.43	1.09	0.0	.72	.73
Other	.45	0.0	.11	0.0	0.0	.10
Total	99.55	99.04	99.42	98.79	100.00	99.30
Forbs						
Artemisia	0.0	0.0	0.0	.27	0.0	.07
Boraginaceae	0.0	0.0	.06	0.0	0.0	.03
Compositae	.45	0.0	0.0	0.0	0.0	.04
Equisetum	0.0	0.0	.04	0.0	0.0	.02
Lupinus	0.0	0.0	.05	0.0	0.0	.03
Phlox	0.0	0.0	0.0	.11	0.0	.03
Other	0.0	0.0	.09	0.0	0.0	.04
Total	.45	0.0	.24	.38	0.0	.26
Browse						
Picea	0.0	.48	0.0	.30	0.0	.12
Pseudotsuga	0.0	.48	.34	.42	0.0	.32
Salix	0.0	0.0	0.0	.11	0.0	.03
Total	0.0	.96	.34	.83	0.0	.47

(_)=number of composite samples in the locale

Table 4.7 Distribution of elk (% observations) in relation to shade and snow depth.

Parameter	Shade Cover			Snow Depth (dm)		
	None	Partial	Total	0-1	1-6	>6
Total Obs.	42.0	11.0	47.1	67.5	11.4	21.2
Slope						
Gentle	53.3	42.9	47.5	55.2	34.5	38.9
Moderate	40.2	57.1	35.0	39.0	41.4	40.7
Steep	6.5	0.0	17.5	5.8	24.1	20.4
Aspect						
N	0.0	0.0	2.5	1.7	0.0	0.0
NW	.9	3.6	1.7	.6	3.4	3.7
NE	0.0	0.0	.8	.6	0.0	0.0
W	9.3	14.3	10.8	11.6	6.9	9.3
E	15.9	3.6	8.3	14.0	10.3	1.9
SW	29.9	10.7	26.7	19.2	31.2	46.3
SE	15.9	32.1	21.7	23.3	17.2	13.0
S	27.1	35.7	25.8	27.3	31.0	25.9
Nil	.9	0.0	1.7	1.7	0.0	0.0
Range type						
Grassland	84.1	82.1	75.0	82.0	58.6	83.3
Low shrub	2.8	0.0	2.5	.6	13.8	1.9
Mix. dec. for.	.9	3.6	1.7	1.7	3.4	0.0
Doug. fir for.	0.0	7.1	.8	1.7	0.0	0.0
Grass/Conifer	12.1	7.1	20.0	14.0	24.1	14.8
Mixed forest	0.0	0.0	0.0	0.0	0.0	0.0

4.3.5.2 Mule Deer

Mule deer were usually observed in totally shaded conditions (Table 4.22). Not unexpectedly, shaded mule deer were observed more often on north and west aspects in forested range types.

As snow depth increased, mule deer were increasingly observed on moderate and steep slopes, east and west aspects, and on grassland range. When snow exceeded 6 dm, mule deer were usually observed on south and west grassland slopes.

One instance of use of a cattle salt station was reported; the soil adjacent to the salt block was licked, not the salt block. Locating the preferred water and salt sources in a given area was confounded by the numerous small streams present in the hills, and the fact that old salt stations could be good salt sources for mule deer.

4.3.5.3 Cattle

Cattle were observed equally in total shade or unshaded conditions (Table 4.9). Not unexpectedly, shaded cattle were observed more often in forested range types and on north and west aspects.

Snow rarely exceeded 2 dm in depth, and was not present for any length of time while cattle were on the area (Section 4.3.1.3). Other weather characteristics, heat and wind, may have had substantially greater effects on cattle activity but required more data than the base station

Table 4.8 Distribution of mule deer (% observations) in relation to shade and snow depth.

Parameter	Shade Cover			Snow Depth (dm)		
	None	Partial	Total	0-1	1-6	>6
Total Obs.	27.1	10.6	62.2	79.8	11.2	9.0
Slope						
Gentle	76.5	50.0	53.0	61.3	42.9	58.8
Moderate	13.7	30.0	31.6	26.7	38.1	11.8
Steep	9.8	20.0	15.4	12.0	19.0	29.4
Aspect						
N	2.0	0.0	.9	1.3	0.0	0.0
NW	0.0	0.0	2.6	1.3	0.0	5.9
NE	0.0	5.0	1.7	2.0	0.0	0.0
W	2.0	0.0	12.0	8.7	4.8	5.9
E	15.7	0.0	9.4	10.7	14.3	0.0
SW	19.6	15.0	17.9	14.7	19.0	47.1
SE	19.6	15.0	10.3	12.7	23.8	5.9
S	31.4	45.0	32.5	34.0	38.1	23.5
Nil	9.8	20.0	12.8	14.7	0.0	11.8
Range type						
Grassland	56.9	30.0	60.7	51.3	66.7	88.2
Low shrub	19.6	10.0	14.5	16.0	19.0	5.9
Mix. dec. for.	5.9	30.0	6.0	10.7	0.0	0.0
Doug. fir for.	0.0	10.0	.9	2.0	0.0	0.0
Grass/Conifer	17.6	20.0	17.1	19.3	14.3	5.9
Mixed forest	0.0	0.0	.9	.7	0.0	0.0

readings recorded over the course of the study.

The effects of water or salt on cattle distribution could not be evaluated because of the difficulty in locating the nearest source.

4.3.6 Activity and Range Use

Ungulate range use was not only a function of the species' distribution. The activity of each species was also part of the pattern.

4.3.6.1 Elk

Elk were usually observed foraging but this varied on a seasonal and daily basis (Figure 4.16). Foraging elk were most likely to be observed in winter and spring, around dawn and dusk, below 1500 m altitude, on moderate and steep slopes, and on east and southwest aspects. Travelling elk were most likely to be observed in the fall, at noon and during the afternoon, between 1500 and 1600 m, on gentle slopes, and on east and south aspects. Bedded elk were most likely to be observed in the fall and winter, from mid-morning to the afternoon, above 1600 m or between 1400 m and 1500 m, on gentle slopes, and on southeast, southwest, and west aspects. Other activities (reproduction, aggression or play) had the greatest likelihood of being observed in the fall at dusk. Elk were most easily disturbed in the spring, at mid-morning and noon, at altitudes above 1500 m, and on east, southeast and west aspects.

Table 4.9 Distribution of cattle (% observations) in relation to shade.

Parameter	Shade Cover		
	None	Partial	Total
Total Observations	45.7	8.6	45.7
Slope			
Gentle	75.8	80.6	64.8
Moderate	17.6	19.4	27.3
Steep	6.7	0.0	7.9
Aspect			
N	0.0	0.0	0.0
NW	1.2	0.0	4.2
NE	1.2	3.2	0.0
W	11.5	9.7	15.8
E	5.5	9.7	6.7
SW	12.7	12.9	18.2
SE	12.7	0.0	18.8
S	25.5	22.6	18.8
Nil	29.7	41.9	17.6
Range type			
Grassland	83.6	67.7	80.6
Low shrub	10.9	6.5	5.5
Mixed decid. forest	2.4	9.7	7.9
Douglas fir forest	0.0	0.0	0.0
Grass/Conifer	3.0	12.9	4.8
Mixed forest	0.0	0.0	1.2

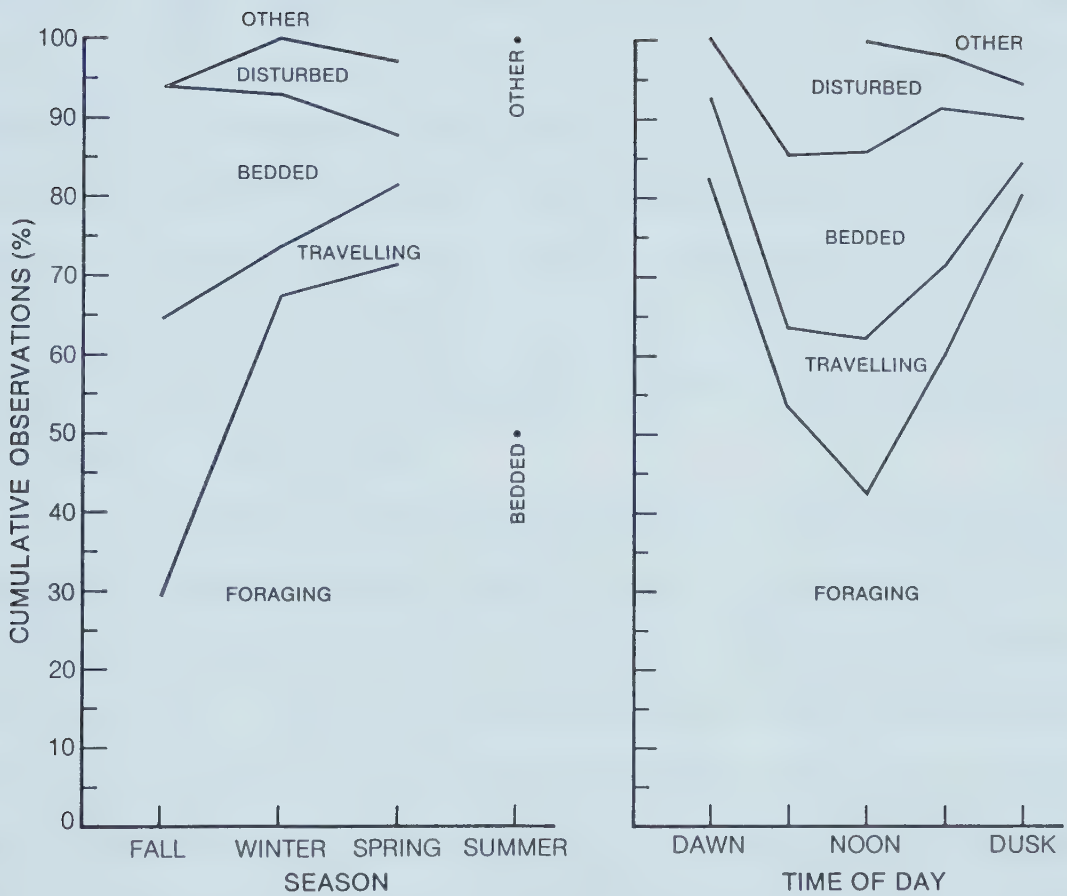

Figure 4.16 Seasonal and diurnal distribution of elk activity.

The vegetation type also had a bearing on elk activity. Foraging elk favoured grass/conifer range more than open grassland, range adjacent to low shrub, mixed forest and mixed deciduous forest types, and distances between 25 m and 100 m from trees and shrubs. Travelling elk favoured forested range types, and range adjacent to grassland range types. Bedded elk selected forest or low shrub communities adjacent to grassland range types; they were generally closer to shrubs than trees. Other activities were usually observed in grassland range types, within 25 m of tree cover. Elk were most likely to be disturbed in or around grassland range and at distances between 100 m and 250 m from tree or shrub cover.

In relation to environmental conditions foraging elk tended to select totally shaded sites and areas with no snow if possible. Travelling elk were most likely to be observed within 25 m to 100 m from a known water source. Bedded elk favoured unshaded areas, and light snow conditions. Other activities were most likely to be observed in total shade. Elk were most likely to be disturbed by the observer from partially shaded sites and between 25 and 100 m from a known water source.

When elk had been disturbed by the observer's activities they usually stood, watchful, or walked in a slow, head-high manner, away from the observer. Those elk which walked or ran from the observer usually selected forest cover (93.5% of observations of disturbed elk). Most

elk (67.9%) went a total distance of less than 250 m before disappearing from view. However, on at least 5 occasions animals were observed still travelling at distances of 1 km from the point of disturbance.

4.3.6.2 Mule Deer

Mule deer were usually observed foraging but this varied according to the season and the time-of-day (Figure 4.17). Foraging mule deer were most likely to be observed in the winter, at dusk or dawn, between 1500 m and 1600 m altitude, on steep slopes, and south aspects. Travelling mule deer were most likely to be observed in the spring and summer, at dawn and noon, below 1400 m, on gentle slopes, and on east, southeast or west aspects. The observer was most likely to disturb mule deer in the summer and fall, in the afternoon, below 1400 m, on gentle slopes, and west aspects. There were too few observations of other activities to warrant interpretation.

In terms of vegetation, foraging mule deer were most likely to be observed in grassland range types, areas adjacent to grass/conifer or grassland range, and within 25 m of tree or shrub cover. Travelling mule deer favoured grass/conifer range or mixed deciduous forest, areas adjacent to low shrub communities, selecting distances between 25 and 100 m from trees and shrubs. Bedded animals selected grass/conifer range, areas adjacent to grassland range types, within 25 m of trees, and over 250 m from

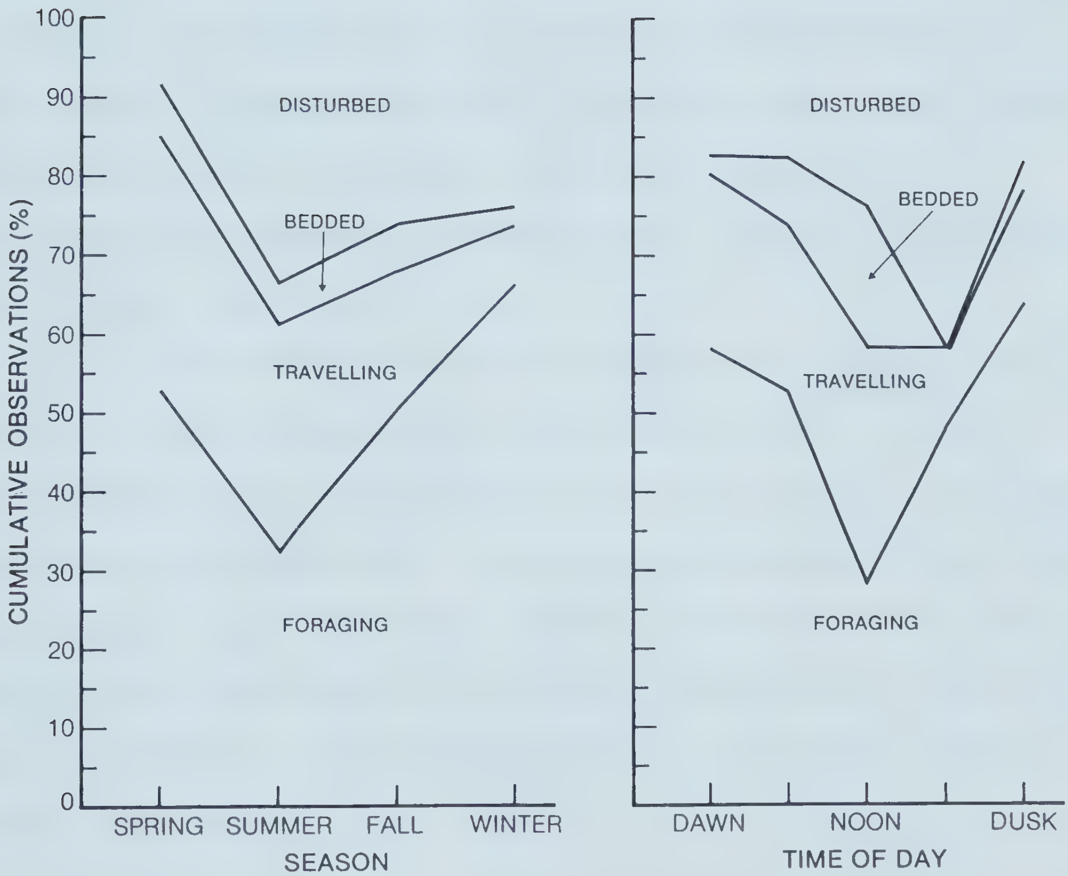

Figure 4.17 Seasonal and diurnal distribution of mule deer activity.

shrubs. The observer was most likely to disturb mule deer in mixed deciduous forest types, in areas adjacent to mixed deciduous forest, within 25 m or over 250 m from trees, and between 25 m and 100 m from shrubs.

Environmental gradients had some effect on mule deer activity. Foraging mule deer selected unshaded sites, while travelling mule deer were most likely to be observed in total shade. Bedded mule deer favoured partial shade where there was no snow. Mule deer were most likely to be disturbed from partially shaded sites, areas with moderate snow depths, and within 100 m of water.

When mule deer had been disturbed they usually left the area (60.7% of the observations of disturbed mule deer). They usually selected forested cover (84.3%) but a few panic stricken individuals ran into open grasslands or low shrub range types. Most mule deer (60.5%) walked or ran a total distance of less than 100 m before disappearing, while fully panicked animals were observed running more than 1000 m before stopping.

4.3.6.3 Cattle

Foraging cattle were most likely to be observed in the spring, at dawn and dusk, below 1400 m altitude, on moderate and steep slopes, and on southwest or southeast aspects (Figure 4.18). Travelling cattle were most likely to be observed in the spring, at noon, below 1400 m altitude, on moderate to steep slopes, and on east aspects. Bedded cattle

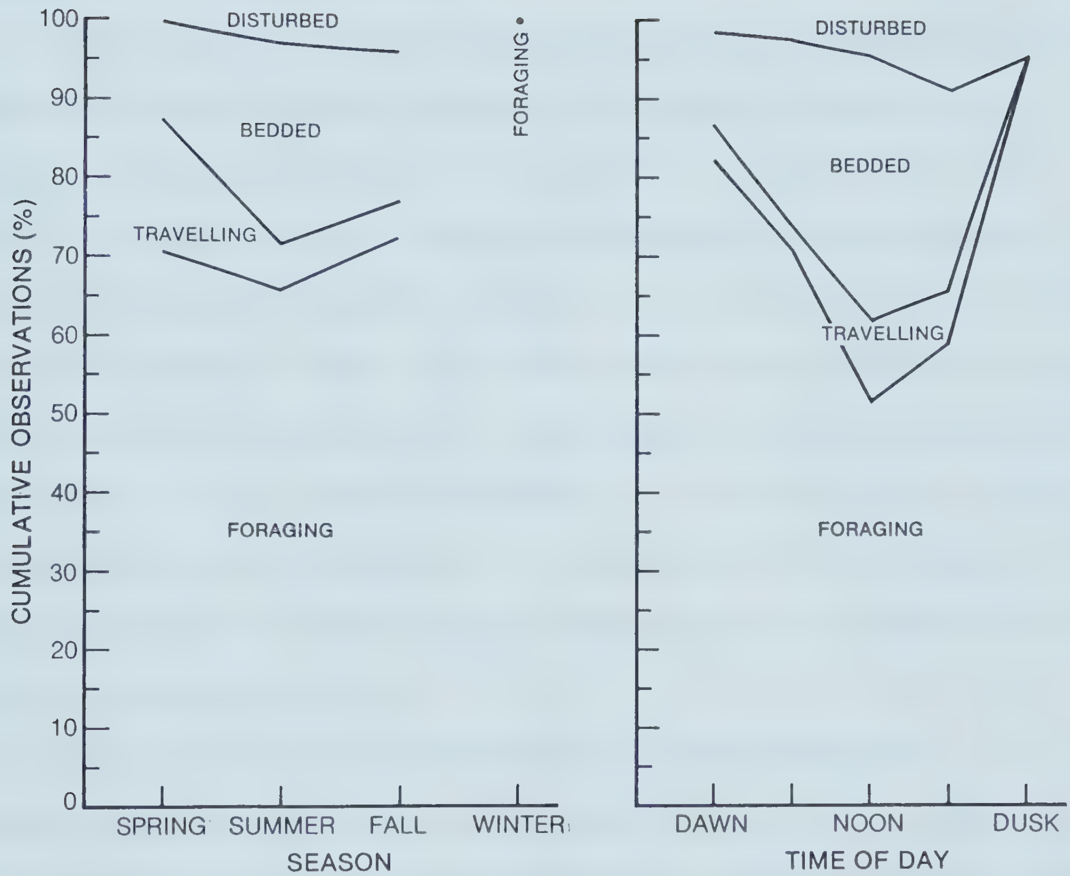

Figure 4.18 Seasonal and diurnal distribution of cattle activity.

were most likely to be observed in the summer, around noon, between 1500 m and 1600 m, on gentle slopes, and on east or west aspects. Few 'other' activities were reported. Cattle were most likely to be disturbed by the observer in the fall, in the afternoon, between 1400 m and 1600 m, on gentle slopes, and on east aspects.

With respect to vegetation, foraging cattle favoured grassland range, areas adjacent to grass/conifer range types, distances between 250 m and 500 m from trees, and within 25 m of shrubs. Travelling cattle also favoured grassland range or areas adjacent to grassland range, and distances between 100 m and 250 m from trees. Bedded cattle selected forested or shrub range types, particularly mixed deciduous forest; areas adjacent to low shrub range, within 25 m of trees, and between 100 m and 250 m from shrubs. Cattle were most likely to be disturbed by the observer from mixed deciduous forest.

Cattle favoured total shade for foraging and travelling. Bedded cattle were most likely to be observed in partial shade and within 25 m of water. Consequently, cattle were most likely to be disturbed from totally shaded areas within 25 m of water.

On 12 occasions cattle were so disturbed by a motor bike that they left the area. Usually (75%) they travelled less than 100 m and selected open grassland (58.3%) or mixed deciduous forest.

4.4 Interpretation of Resource Use

The following discussion is aimed at identifying the strategies used by elk, mule deer, and cattle in selecting particular resources in the Bob Creek Area.

4.4.1 Elk

The social organization of elk has been recently reviewed by Shoesmith (1979) and the most important conclusion is that of the 'generalist' nature of elk behaviour: elk cannot be accurately classified as migratory or sedentary as a species, and their choice of habitat and forage varies with the circumstances surrounding a particular population (Banfield 1974, Craighead *et al.* 1973).

The band sizes of elk in the Bob Creek Area were large when compared with those reported in other areas (Mackie 1970, Picton 1980, Rounds 1980). Extreme limitations in winter range coupled with extensively available spring and summer range may, in part, explain the large size of winter aggregations. However, winter weather seems to have a great impact (Figure 2.2, 2.3, and 4.1) on behaviour and may affect the size of aggregations as well. Snow cover appears to be the major factor influencing the timing of migrations and the size of individual bands. Elk gathered in larger groups more frequently during the mild 1977 winter than the more severe 1978 winter. The largest herds in both winters were observed immediately after heavy snowfalls. The

strategy appears to be that when there is no snow cover, or it is very light, the activities of elk are concentrated on the largest, most amenable areas. As the average snow depth increases, the bands become smaller and more spread out; severe storms may concentrate them again, but only for short periods.

Elk were highly oriented towards a few of the 25 ha cells in the Bob Creek Area. Again, snow cover appears to be the most important factor on these sites. Critical elk winter range cannot, therefore, be exclusively described as the higher altitudes, steeper slopes, southern aspects or open vegetation types on the Bob Creek Area. It must instead be described as small cells or key range sites which, because of site-specific combinations of topography and vegetation, tend to have less snow cover than average.

Elk relied primarily on one plant group, grasses, and more specifically the fescues. The data on diets are not greatly different from those of other elk dietary studies. Hansen and Clark (1977) found elk fecal samples were mostly composed of grasses and sedge (56%). Skovlin and Vavra (1979) found that the percentage of browse and grasses in winter fecal material varied with the area but grasses were always most prevalent.

Elk concentrated specific activities within a fairly narrow range of topographic, vegetational, and environmental features. The amount of activity varied on a temporal basis. For example, elk foraged mostly within specific areas and

increased their foraging effort in winter and spring and at dawn and dusk. This was likely their response to changes in forage quantity and quality, and environmental conditions.

4.4.2 Mule deer

Banfield (1974) described mule deer as normally gregarious during the winter, and somewhat less so in the summer. Mackie (1970) felt the need for association was least important in mule deer, animals tending to band or disband depending on available habitat and food. He observed increasing group sizes in periods when forage quantity and quality were low and felt that mule deer were banding on those sites where forage was more available. Several authors have indicated a threshold level of snow depth may precipitate movement to winter ranges where animals band into larger groups (Kramer 1971, Gilbert *et al*. 1970)

The size of mule deer bands in the Bob Creek Area tended to vary considerably from the average monthly values. The degree of variation probably reflects the individual mule deer's response to climate, habitat and forage availability, and so on, in conjunction with the animal's condition. Movements to ranges which are more amenable will depend primarily on the individual's tolerance for deteriorating conditions in its home range, and its' physical condition.

Weather conditions may have contributed to an earlier and higher peak group size in 1978 (Figs. 2.2, 2.3, and

4.2). Presumably, continuous snow cover and cold temperatures force more deer onto limited areas; the highest band sizes in both winters were observed after snow had blanketed the study area and before winds or temperatures had reduced its cover on south-facing slopes. The strategy of resource use appears to be that the activities of mule deer are normally centred on small home ranges when resources are available. As conditions deteriorate, mule deer tend to aggregate on more limited winter ranges.

Mule deer were highly oriented towards a few of the 25 ha cells in the Bob Creek Area. Snow depth appears to be one of the most important factors dictating the use of these key range sites. Critical mule deer winter range can therefore be described as those sites with southern and western aspects, and more coniferous and shrub vegetation, which tend to have less snow cover than average.

Douglas fir contributes heavily to the winter diets of mule deer in the Bob Creek Area, in comparison to mule deer diets reported for other regions. In Montana, Constan (1972) recorded Douglas fir in only 2% of the instances of winter plant use for mule deer, although animals were mostly observed within the Douglas fir range type over the winter period. Nellis and Ross (1969) found an average of 20.7% Douglas fir in rumens of wintering mule deer.

Mule deer varied their activity on a temporal basis. A particular activity was commonly associated with a fairly narrow range of spatial, topographic, and vegetational

features. The time spent in a particular activity increased or decreased seasonally, probably in relation to forage quantity and quality, and daily in relation to changing environmental conditions.

4.4.3 Cattle

Arnold and Dudzinski (1978), state that the size of aggregations in a herd of 300 cows varied from 4 to 11 animals. Apparently, these animals had been grazing the area for some time, so most animals were familiar with it. Cattle in the Bob Creek Area were mostly yearlings, and although yearlings often range further, their inexperience with grazing, and with the area, may contribute to higher average group sizes.

The grazing system for cattle in the Bob Creek Area is highly regulated. Within the Forest Reserve, permittees were required to ride and salt the animals to effect better distribution. These activities should break up large groups and move cattle away from areas where they were turned-in. This is one possible reason for the observed decrease in average group sizes after cattle were turned into the study area. Additionally, Arnold and Dudzinski (1978) indicate that as vegetation becomes senescent and the quantity available falls, the average size of aggregations is reduced. Thus, lower group sizes and greater dispersion of groups would be expected as the grazing season progressed.

Cattle were highly oriented towards a few 25 ha cells on the Bob Creek Area. Distance to water was one of the major factors affecting this distribution.

Cattle relied on one plant group, grasses, and specifically the fescues for forage. Cattle are known to select diets composed primarily of grasses, limiting their intake of forbs and browse (Kothmann 1980). Selection may alter with the seasonal availability, preference, and palatability of the forage. In this study, the greatest variety of forbs were found in diets from the middle third of the Bob Creek region while the greatest amount of forbs were found in diets from the Spring Creek and southern third of Bob Creek. These latter areas were grazed earlier by cattle (beginning 15 June in the Forest Reserve and earlier on private land) while the former was grazed by more cattle. Although no significant difference exists, based on rankings between these three locales, there does appear to be some evidence of differential selection between these areas.

Cattle showed only slight variations in the seasonal distribution of a particular activity, possibly because the availability and quality of forage remained high through the grazing season. In contrast certain activities were much more prevalent at particular times of the day, probably in response to changing environmental conditions. As with elk and mule deer, particular activities were associated with a fairly narrow range of spatial, topographical and vegetational features.

5. RESOURCE DIVISION

5.1 Introduction

Hanley (1982b) determined that resource division (an observed separation in resource use, also referred to as partitioning) between ungulates is related to the characteristics of animals and the available forage base. He suggested that facilitative (synergistic) grazing systems, similar to those of East and South Africa (Sinclair and Norton-Griffiths 1982) could exist between livestock and wild ungulates on North American rangelands. There are few precedents for this suggestion. A great deal of evidence has been compiled (Mackie 1978) that supports the theory of non-facilitation: negative consequences have generally resulted from livestock grazing. However, this should not be unexpected given past land use policies (Dana and Fairfax 1980). It may be that non-facilitation is more a result of poor management practices than it is of competitive relationships.

In fact there is evidence of resource division and facilitation in North American grazing systems. Hudson (1976, 1977) found evidence of resource separation among elk, white-tailed deer, mule deer and big horn sheep in the Rocky Mountains. Schwartz and Ellis (1981) reported dietary separation among bison, cattle, pronghorn antelope and domestic sheep on the Central Plains. Hanley and Hanley

(1982) described dietary separations between feral horses, cattle, domestic sheep, pronghorn antelope and mule deer on Great Basin rangelands. Skovlin *et al*. (1968) and Julander and Jeffrey (1964) have shown that elk, mule deer and cattle have different habitat selection strategies. Anderson and Sherzinger (1975) deduced that management changes could ameliorate conflicts between cattle and elk and facilitate grazing by both species.

In this section the modes of resource division are described for ungulates in the Bob Creek Area. By describing these divisions two things may be possible. Firstly, they may provide evidence of interaction (competitive or synergistic relationships) between the ungulates. And secondly, the description of divisions in resource use may be important for management decisions related to ungulate use.

5.2 Methods

Ecological theorists have developed a number of ways to measure species relationships. Generally, these measures describe the size of the niche (diversity or niche breadth); the character of the species (predator or prey); the amount one species uses of another species niche (overlap); and the response of one species to the presence of another (association or dissociation). Most of the theory has been derived from studies of invertebrate, avian, and small

mammal communities but recent applications include ungulates (Schwartz and Ellis 1981, Hansen and Clark 1977, Nelson 1982, Compton 1975) and grazing systems (Noy-Meir 1975).

The statistics chosen to describe the divisions in resource use between species in the Bob Creek Area were measures of diversity, overlap and association. Separate calculations were made for the animal observation and fecal group count data summaries on 8 selected temporal, spatial, topographical and dietary resource parameters.

Duncan's multiple range test (P=.05) was used to assess the differences between mean diversities and mean overlap. Specific diversities (niche breadths for each species) on a resource parameter were compared with the Z-statistic (P=.05) (Lyons 1981). Spearman's coefficient of rank correlation (P=.05) was used to measure association and evaluate the overlap between species.

5.2.1 Diversity

Numerous definitions have been applied to the term diversity (Hill 1973, Hurlbert 1971, Petraitis 1979), but most reduce the concept to 2 functions. Ecological diversity is a function of:

1. the total number of species or resources;
2. the proportion contributed by each species or resource to the total variation.

Generally, if a resource is equally available for all species, those species with low diversities are more

selective of parts of that resource than species with high diversities. Additionally, if a species population increases in density or the resource decreases in availability, that species' diversity may increase.

Diversity was calculated using a coefficient referred to as the Shannon-Weaver information statistic (Hurlbert 1971). Further, each diversity coefficient was standardized to vary from 0 to 1 by dividing it by the maximum diversity: an artificial value that assumes the even distribution of a species over a resource parameter. Lyons' (1981) equations were used to estimate the variance.

5.2.2 Overlap and Association

Simply put, overlap is the amount of a resource jointly used by two or more species. It is a reciprocal index of resource division: a high overlap between two species implies little resource division. Theoretically an understanding of overlap may lead to derivations of the competitive ability of each species. Practically, it may only provide an understanding of the current division of resources between species (Armstrong and McGehee 1980, Hurlbert 1978, Schoener 1974, Thomson and Rusterholz 1982).

A wide variety of overlap indices are available. Since Horn's Ro (Horn 1966) is an extension of the Shannon-Weaver index of diversity, it was judged to be the most appropriate. Ro has a range from 0 (no overlap) to 1 (complete overlap).

A measure of overlap provides no information on the strength of the relationship between species. While it may normally be true that high overlap indicates a positive association between species (and conversely low overlap indicates dissociation) the amount of overlap conveys no information about its significance. However, rank order correlation, as suggested by Hansen and Clark (1977), provides a suitable test of significance of the relationship, as well as an evaluation of association.

Accordingly, Spearman's rank order correlation coefficient, Rho, was used to test the null hypothesis that the two species were mutually independent (i.e. they had no association) on a resource (P=.05) (Conover 1980, p. 254). A negative and significant correlation indicates a large division of that resource, and that the species are dissociated on that resource (where one species is present the other species is not). A positive and significant correlation indicates little division of the resource, and that the species are associated on that resource (where one species is present the other is too).

5.3 Results and Discussion

By definition, 6 of the 8 selected resources were equally available for every ungulate species. Thus, there were 4 seasons, 5 periods-of-the-day (Day), 4 altitude groupings, 3 slope categories, 9 aspects, and 6 habitats

available for every species. Consequently, higher or lower diversities on these parameters could be directly interpreted as differences in selectivity.

However, 2 of the selected resources, spatial distribution of observations in 25 ha cells (Space), and plant materials in feces (Diets), were not equally available for each species. For example, mule deer were observed in 111 of 466 possible spaces (25 ha cells), while elk were observed in 129, and cattle in 154. There were, therefore, fewer spaces available for mule deer than for cattle. If mule deer were distributed in their 111 spaces more evenly than cattle were in their 154 spaces, mule deer would have a higher diversity than cattle.

In order to hold the resource constant, diversities were calculated for those spaces (25 ha cells) where each species was jointly observed with another species. In this case, elk and mule deer used 55 spaces jointly; elk and cattle, 47 spaces; and mule deer and cattle, 51 spaces.

A similar situation existed for the diets. Mule deer had 15 plant sources, while elk had 20, and cattle, 21. Mule deer could have a higher diversity than cattle, if they used their diet sources in more even proportions than cattle.

Elk, mule deer, and cattle were equally diverse in their use of the Bob Creek Area (mean diversity, Table 5.1). Each combination of species (elk-mule deer, elk-cattle, mule deer-cattle) had an equal average amount of overlap (mean overlap, Table 5.3). An ungulate may have been more or less

diverse, and each pair of species may have had more or less overlap on individual resources, but overall, the levels of diversity and overlap sustained by each species were equivalent. This similarity also occurred between the different data collection methods: mean animal observation diversities and overlaps (Tables 5.1, 5.3) were not significantly different from mean fecal group diversities and overlaps (Tables 5.5, 5.6).

5.3.1 Seasonal Interactions

5.3.1.1 Diversity

Mule deer were observed consistently in every season in contrast to elk or cattle. So, in terms of seasonal use, mule deer were significantly more diverse than either elk or cattle (Tables 5.1, 5.2).

Elk and cattle were equally diverse seasonal users. Although elk and cattle occupied the area for relatively distinct time periods, they had an equivalent seasonal presence.

In terms of the daily cycle of activity, elk, mule deer and cattle diversities were also equivalent. Thus, they were equally selective in their daily patterns of resource use.

5.3.1.2 Overlap and Association

Elk and cattle occupied the area at different times, hence they had the least seasonal overlap (Table 5.3). Elk were also seasonally dissociated, that is there were few elk

Table 5.1 Diversity of elk, mule deer and cattle in the Bob Creek Area (observation data).

Resource	Diversity*								
	All Observations			Joint Use Areas					
	Elk	Deer	Cattle	Elk/Deer		Elk/Cattle		Deer/Cattle	
Season	.66	.95	.62						
Day	.96	.94	.93						
Space	.95	.96	.94	.94	.95	.95	.92	.97	.92
Altitude	.83	.87	.76	.80	.83	.86	.82	.80	.70
Slope	.87	.86	.69	.94	.90	.81	.80	.83	.74
Aspect	.77	.83	.83	.74	.81	.84	.84	.82	.75
Habitat	.38	.68	.40	.38	.68	.30	.23	.63	.32
Diets	.23	.19	.19						
Mean	.71	.79	.67	.76	.83	.75	.72	.81	.69

* Diversity varies from 0 (nonexistent) to 1 (even distribution over the available resource).

Table 5.2 Comparisons of diversity for elk, mule deer, and cattle (Z-statistic on observations).

Resource	Comparisons of Diversity (Z)					
	All Observations			Joint Use Areas		
	Elk & Deer	Elk & Cattle	Deer & Cattle	Elk & Deer	Elk & Cattle	Deer & Cattle
Season	-2.50*	.40	2.93*			
Day	.14	.21	.05			
Space	1.67*	-1.39	-3.00*	.67	1.19	2.49*
Altitude	-.30	.79	1.04	-.20	.25	.58
Slope	.11	1.80*	1.49	.22	.06	.53
Aspect	-.47	-.58	-.01	-.48	-.03	.42
Habitat	-3.33*	-.33	3.19*	-2.46*	.85	2.49*
Diets	.85	.48	-.36			

* Diversities are significantly different, P=.05

on the Bob Creek Area when there were many cattle (Table 5.4).

Elk and mule deer had similar daily activity periods while that of cattle was slightly, but not significantly different.

5.3.2 Spatial and Topographical Interactions

The distribution of ungulates over the range (their use of space) is related to the selective behaviour of each species, to the number of sites available, and to the particular group of attributes present at each site.

5.3.2.1 Diversity

Mule deer were slightly more diverse in their spatial distribution than either elk or cattle (Table 5.1). Largely, this is a result of mule deer being more evenly distributed amongst the 111 cells in which they were observed. In comparison, elk were less evenly distributed amongst the 129 cells in which they were observed, and cattle, on 154 cells, were less evenly distributed than elk. This pattern of range use was also evident for those cells where pairs of species were observed jointly (joint use areas). The more even distribution of mule deer may be caused by a greater density of mule deer than the 111 cells would normally support, or some behavioural characteristic of mule deer which keeps them from aggregating as much as the other species.

Table 5.3 Overlaps (Ro) of elk, mule deer and cattle in the Bob Creek Area (observation data).

Resource	Overlap (Ro)*					
	All Data			Joint Use Areas		
	Elk & Deer	Elk & Cattle	Deer & Cattle	Elk & Deer	Elk & Cattle	Deer & Cattle
Season	.85	.30	.69			
Day	.97	.91	.95			
Space	.45	.36	.30	.87	.81	.88
Altitude	.89	.84	.97	.98	.95	.98
Slope	.99	.96	.98	1.00	.99	1.00
Aspect	.94	.87	.96	.98	.94	.97
Habitat	.92	.95	.94	.92	.96	.93
Diets	.22	.98	.12			
Mean	.78	.77	.74			

* Overlap varies from 0 (none) to 1 (total).

Table 5.4 Association (Spearman's Rho) of elk, mule deer and cattle in the Bob Creek Area (observation data).

Resource	Rank Order Correlation Coefficient (Rho)					
	All Data			Joint Use Areas		
	Elk & Deer	Elk & Cattle	Deer & Cattle	Elk & Deer	Elk & Cattle	Deer & Cattle
Season	.40	-1.00*	-.40			
Day	.40	-.10	-.30			
Space	-.29*	-.50*	-.38*	.10	-.19	.30*
Altitude	-.40	0.0	.80*	1.00*	.80*	1.00*
Slope	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Aspect	.83*	.55	.88*	.95*	.55	.98*
Habitat	1.00*	.77*	.77*	.99*	.90*	.94*
Diets	.30	.64*	.08			

* Significantly correlated, P=.05
Rho varies from -1.00 (completely dissociated) through 0 (mutually independent) to 1.00 (completely associated).

Because mule deer were observed on fewer cells than either elk or cattle, they were significantly less diverse in their distribution over the Bob Creek Area as a whole, than elk or cattle (Table 5.2). Statistical treatment of the joint use data revealed the other pattern of diversity: mule deer were significantly more diverse, that is they were distributed amongst a constant set of cells more evenly than cattle. The diversities of elk and mule deer, and elk and cattle on joint use areas were not significantly different.

For the specific attributes altitude, slope and aspect, cattle were less diverse, and hence more selective, than mule deer and mule deer were more selective than elk. (Average diversities of elk, mule deer, and cattle were .84, .81, and .76 respectively for these attributes over all data sets. Average diversities on the different data sets were .82, .85, .76 for observations; .85, .76, .76 for fecal group counts.)

The slope parameter had the only significant trend: cattle tended to be the least diverse, mule deer more diverse, and elk the most diverse users of slopes (Tables 5.2, 5.5).

Thus, the distribution of ungulates within the Bob Creek Area is primarily a function of the number of 25 ha spaces (range sites). Cattle have, in general, more range sites available than elk or mule deer, but they utilize them less uniformly (that is, some sites are highly favoured, resulting in higher proportional use of these sites). At the

Table 5.5 Comparisons of diversity for elk, mule deer and cattle (Z-statistic on fecal distributions).

Resource	Diversity**			Comparison of Diversity (Z)		
	Elk	Deer	Cattle	Elk & Deer	Elk & Cattle	Deer & Cattle
Altitude	.77	.69	.73	1.10	.72	-.64
Slope	.91	.90	.74	.13	3.10*	1.91*
Aspect	.88	.69	.82	4.65*	1.17	-3.65*
Habitat	.34	.57	.26	-1.38	2.88*	1.84*
Mean	.72	.71	.64			

* Diversities are significantly different, P=.05
** Diversity varies from 0 (nonexistent) to 1 (even distribution over the available resource).

other extreme, mule deer have the least number of sites available, and these are utilized more uniformly. Elk are intermediates. In addition, the ungulate ranges in the Bob Creek Area are not large, continuous areas of distribution. They are small, sometimes contiguous sets of range sites, usually less than 25 ha in size. The more important range sites act as centres-of-distribution: most animals will be observed within or immediately adjacent to these sites.

5.3.2.2 Overlap and Association

Ungulate species are segregated in space in the Bob Creek Area. Elk, mule deer and cattle each selected different range sites and therefore had little spatial overlap (Table 5.3). In addition, they were dissociated from one another in space (Table 5.4). Thus, each species appears to occupy a set of mutually distinct range sites.

This factor is important for operational management planning. Resource improvements are normally targetted at only one species. Any associated species should remain unaffected or, at best, be enhanced by the improvement. Thus, those areas where improvements are planned should be important only to the one species for which improvements are planned (other species' distributions are significantly dissociated or negatively correlated) or neither species (species' distributions are mutually independent or not significantly correlated).

High overlap occurred on joint use areas because both species were always present in each 25 ha cell (Table 5.3). However, elk and mule deer distributions were mutually independent on joint use areas (Table 5.4), implying that they oriented towards different range sites in the Bob Creek Area. Similarly, elk and cattle had no strong association. However, mule deer and cattle had a significant, positive association: some 25 ha cells were important to both species. Thus, elk and mule deer, and elk and cattle have spatial divisions in their use of the Bob Creek Area, but mule deer and cattle have not.

Overlap on altitude, slope and aspect is high for all species pairs (Tables 5.3, 5.6). If resources are divided on the basis of topography, these coefficients should reflect a negative association between species. However, the distributions of species are mostly mutually independent or significantly, positively correlated. The only exception occurs for elk and mule deer fecal group distributions. These are negatively associated on slope: that is, fecal group counts for elk are high on those slopes where fecal group counts for mule deer are low and vice versa. Thus, topographical resources do not appear to be divided except in the circumstance where elk and mule deer have opposite defecation behaviours on slopes.

Table 5.6 Overlaps (Ro) and associations (Spearman's Rho) of elk, mule deer and cattle in the Bob Creek Area (fecal distribution data).

Resource	Overlap** (Ro)			Correlation Coefficient (Rho)		
	Elk & Deer	Elk & Cattle	Deer & Cattle	Elk & Deer	Elk & Cattle	Deer & Cattle
Altitude	.97	.91	.97	1.0*	.80*	.80*
Slope	.85	.80	.81	-1.0*	-.50	.50
Aspect	.87	.89	.84	.45	.42	.20
Habitat	.96	.96	.94	1.0*	.83*	.83*
Mean	.91	.89	.91			

* Significantly correlated, P=.05
** Overlap varies from 0 (none) to 1 (total).
Rho varies from -1.00 (completely dissociated) through 0 (mutually independent) to 1.00 (completely associated).

5.3.3 Interactions Within Plant Communities

5.3.3.1 Diversity

Elk were the most selective (least diverse) users of habitat in comparison with cattle or mule deer (Tables 5.1, 5.2, 5.5). All species were strongly oriented towards open grassland. Mule deer were observed more often in shrub and forested range types than either of the other species, hence they were the most diverse users of habitat.

5.3.3.2 Overlap and Association

The use of plant communities was characterized by high overlaps and positive associations between species pairs (Tables 5.3, 5.4, 5.6). Range resources are not divided, at least at the level of discrimination employed in this study; the coefficients for range selection are neither small nor negative.

5.3.4 Dietary Interactions

5.3.4.1 Diversity

Cattle diets contained the greatest number of components, and mule deer the least but the diversities of ungulate diets were not significantly different (Table 5.1, 5.2). What a species lacks in variety it apparently makes up for by making a more even selection.

5.3.4.2 Overlap and Association

Overlap between the diets of elk and mule deer and between mule deer and cattle (Table 5.3) were expected to be low because few materials were selected in common. However, the diets were not completely distinct or dissociated (Table 5.4). The diets of elk and mule deer and of mule deer and cattle were mutually independent of one another. The division of the forage resource has not apparently reached the stage where diets are mutually exclusive, although they are segregated to a high degree.

Dietary resources are undivided for elk and cattle; their diets are highly overlapped and positively correlated.

5.4 Resource Division and Ungulate Interactions

In the Bob Creek Area, through nearly 100 years of trial and error, a situation has evolved that appears to satisfy the requirements of each ungulate. Elk and cattle resource use is divided primarily in time, and secondarily in space; elk and mule deer resource use is divided primarily in space, and secondarily by forage; mule deer and cattle resource use is divided primarily by forage. Because livestock distribution is easily affected by changes in livestock management (eg. herding, fencing, water and salt placement), the narrowest division of resources probably occurs between elk and cattle. As long as the management of the grazing system remains intensive, that is, shifts in use

6. SYNTHESIS AND MANAGEMENT

6.1 Synthesis

The dynamics of native grazing systems are functionally related to the production and consumption of vegetation, to the density of herbivores, and to the system's diversity (Harrison 1979, Noy-Meir 1975, Noy-Meir 1978). A serious disruption to the system will usually result in a succession of communities as the system gradually adapts to the disturbance (Connell and Slayter 1977). In the process, herbivores may compete for the available resources and divide them in a manner that ensures the survival or extinction of the population (Armstrong and McGehee 1980). Management can have a significant impact at any stage in the process.

This investigation examined the relationships that have developed between wild and domestic ungulates in the Bob Creek Area.

6.1.1 Evaluation

Since the late 1800's there have been several major disruptions to the native grazing system in the Bob Creek Area. The extinction of bison and the reduction of other ungulates had probably the most significant, long-term effect. The introduction of cattle and the reintroduction of elk, in conjunction with an active program of fire

by either domestic or wild ungulates are either approved or countered by shifts in management, it should be possible to maintain these levels of resource division indefinitely.

Three measures (diversity, overlap and association) provided summary descriptions of the current patterns of resource use and resource division. These indices are simply measures; they do not explain the reason for the patterns. Furthermore, diversity, overlap and association values only provide a picture of the state of resource use at one time. Thus, they cannot measure the amount of competition or the degree of facilitation between species because competitive or facilitative interactions affect species' populations through time. Perhaps, if enough time periods were analysed, these measures could be used to deduce the amount of competition in the system. For the ungulates in the Bob Creek Area, this deduction is not possible because there is not enough information available.

Measures of diversity, overlap and association are sensitive to changes in population density and resource availability. They are therefore extremely useful as monitors of the effect of management on the distribution of species. They could prove to be suitable measures in multiple use situations or where the management goal is to maintain each species by creating, or fostering, distinctive resource divisions.

suppression and predator control was probably the most serious. Although fire suppression requirements were relaxed in the 1950's (low fuel levels were previously maintained by high grazing rates) the vegetation still shows evidence of its adaptation to systematic overuse.

My thesis is that a division or partitioning of resource use has occurred between the ungulates in the Bob Creek Area. Resources appear to be divided in a manner that could reduce the level of conflict between species; for example, if two species eat the same food, they may use different areas. Whether these divisions have occurred as a result of competitive or facilitative interactions, or management could not be deduced. Therefore, management programs aimed specifically at reducing competition may first require experimental manipulation of the grazing system to determine if lack of competition is actually an improvement.

6.2 Grazing System Management

From the distribution of observations and fecal group counts, ungulates in the Bob Creek Area appear to concentrate their use around a number of small, mutually exclusive, and relatively homogeneous areas. These areas contain a particular combination of topography and vegetation that meet their temporal requirements under a variety of environmental conditions. Resource management

will have a large effect on each species firstly by maintaining or increasing the number of these key range sites, and secondly by improving the value of particular sites or their area of influence.

6.2.1 Elk

Key range sites for elk in the Bob Creek Area do not appear to total more than 700 ha. They are small units, probably less than 25 ha each, but they may be contiguous. They are often snow-free, in open grassland, and adjacent to grass/conifer range. Fescues are the preferred forage in these areas.

The most important key range sites for elk are in the area east of Spring Creek (Camp Creek) in and around a ridge locally known as Sailor Jack (Section 1, Twp. 11, Rge. 3, W5 Meridian; and NE 1/4 of section 35, N 1/2 of 36, Twp. 10, Rge. 3, W5). A second set of key range sites is located on the eastern flank of the Whaleback Ridge (beginning in NW 1/4 of 2 and NE 1/4 of 3, Twp. 11, Rge. 2, W5 and extending northwest along the ridge to S 1/2 of 22, Twp. 11, Rge. 2, W5). A third set of key range sites is located in the hills north of Coyote Creek (N 1/2 of 32, Twp. 10, Rge. 2, W5; E 1/2 of 5, Twp. 11, Rge. 2, W5).

Reductions in elk productivity could be expected if the grassland was radically disturbed or if the elk were continuously harrassed on these primary sites. Increases in elk productivity could be expected if improved forage was

provided either on or adjacent to these areas.

Smaller, more isolated, secondary key range sites are scattered throughout. One of these is present in the valleys at the southern tip of the Whaleback Ridge (NE 1/4 of 22, Twp. 10, Rge. 2, W5). Another is between the two hills south of Coyote Creek (SW 1/4 of 33, Twp. 10, Rge. 2, W5). Others are found on the west flank of the Whaleback Ridge (at the heads of Coyote and Beaverdam Creeks), on the two small ridges north of Beaverdam Creek, on the east flank of the ridge between Bob Creek and Spring Creek, and on the ridge east of Miles Coulee in the Spring Creek drainage. These sites appear to be less important; usually no more than 3 observations of small elk bands were made in the vicinity of these sites.

Slight increases in elk productivity could be expected if the forage production on or near these secondary sites was increased. Disturbance to these sites may inconvenience a few animals, but it should not significantly affect their overall production in the Bob Creek Area.

6.2.2 Mule Deer

Key range sites for mule deer appear to be smaller and fewer than those for elk. As snow depth increases, mule deer tend to band in large groups on these sites. The sites are often snow-free grass/conifer ranges of mixed limber pine and Douglas fir communities. The principal forage is Douglas fir and other browse species which may be in the vicinity.

Key range sites for mule deer do not appear to exceed 600 ha in total area and most of the sites are contiguous.

The most important set of key range sites for mule deer are on the ridges and slopes at the southern tip of the Whaleback Ridge (N 1/2 of section 22, and SW 1/4 of 27, Twp. 10, Rge. 2, W5). Another set of key range sites are located in the hills south of Coyote Creek (SW 1/4 of 33, Twp. 10, Rge. 2, W5) and east of Bob Creek (N 1/2 of 31, Twp. 10, Rge. 2, W5). And several sites exist in the area around Sailor Jack, the ridge east of Spring Creek (NW 1/4 of 36, Twp. 10, Rge. 3, W5 and SW 1/4 of 1, Twp. 11, Rge. 3, W5).

The relatively low number of sites used by wintering mule deer may, in part, explain the lower population levels of this species. Any reductions in available browse or harassment of mule deer on these sites could be expected to have severe consequences for the mule deer population in the Bob Creek Area.

Browse improvement programs would be effective if they either improved Douglas fir, or substantially increased the quality and availability of other browse within or adjacent to the key range sites.

6.2.3 Cattle

Key range sites for cattle appear to be comparable to elk in total area, about 700 ha. Cattle tend to aggregate on these sites in large numbers despite good management efforts to distribute them. (53% of the 9,005 head observed during

the study were located on these sites). These key range sites are usually on relatively flat land, near the larger water sources. The adjacent forest cover is mostly aspen and in some areas it is invading the sites. On native range, fescues are the primary forage.

The most important key range sites for cattle are those tame pasture lands east of the A7 ranch house (W 1/2 of section 5, Twp. 11, Rge. 2, W5) and on a bench east of Bob Creek, 3 km north of the ranch headquarters (E 1/2 of 18, Twp. 11, Rge. 2, W5). Further north, several large sites occur in the bottom land along Bob Creek (E 1/2 of 19, W 1/2 of 32, Twp. 11, Rge. 2, W5; and S 1/2 of 5, Twp. 12, Rge. 2, W5). In the Spring Creek area, the key range sites are also on bench lands or lowland, one adjacent to a campsite maintained by the province (NE 1/4 of 2, Twp. 11, Rge. 3, W5), one on the benches east of Miles Coulee where a dam has been constructed (SE 1/4 of 23, Twp. 11, Rge. 3, W5), and one on the open land east of Spring Creek (E 1/2 of 24, Twp. 11, Rge. 3, W5). Several key range sites were also present on Beaverdam Creek (SW 1/4 of 16 and SE 1/4 of 17, Twp. 11, Rge. 2, W5). A few head ranged the grassland in Eagle Coulee (S 1/2 of 28, Twp. 10, Rge. 2, W5) and cows and calves from the Waldron Grazing Co-operative used the drainage in the Whaleback Ridge (E 1/2 of 27, Twp. 10, Rge. 2, W5).

Several areas would benefit through contouring or reseeding. Erosion is significant on several sites; in some cases the operators are hard-pressed just to maintain

culverts. Reseeding to tame forage could be beneficial on Beaverdam Creek (W 1/2 of 16, Twp. 11, Rge. 2, W5) and on Bob Creek (E 1/2 of 29, Twp. 11, Rge. 2, W5; SE 1/4 of 5, Twp. 12, Rge. 2, W5). More intensive grazing on tame forage in these areas may also require fencing to protect the stream banks, especially on Bob Creek.

6.2.4 Range Management

Range management should be geared towards the creation of more key range sites, and a greater proportion of the major forage species in the Bob Creek Area.

Management to increase the proportion of fescues in native grassland would require reductions in the stocking rates of both elk and cattle. However, large reductions in the grazing rate may be required to produce only a moderate effect on grassland dynamics.

Alternatively, increasing the amount of tame forage, and reducing cattle stocking rates on native grasslands in proportion to the additional tame forage produced would be both flexible and progressive. Under this strategy, a large improvement in fescue productivity could be harvested by increasing cattle stocking rates for short periods.

Brush control will be required if present stocking rates for cattle are to be maintained. Shrubby cinquefoil, snowberry and aspen are invading large areas west of the Whaleback Ridge from Beaverdam Creek north. Although burning has been attempted it will be effective only if practised on

a continuing basis. (Spraying and burning would be more effective, but may not be approved because of the streams in the vicinity.)

Livestock reductions, if considered, would be experimental. They would have a useful purpose primarily to determine if the grazing system is facilitative (total productivity of each ungulate is greater as a result of joint use), or if the ungulates were influenced by competition. To be effective, reductions should be greater than 25% of the current stocking rate, and should be effective for at least 5 years. They would be most logically applied to the centre distribution unit in the Bob Creek allotment, given the current fencing arrangements, productivity and use in this area.

6.3 Management of Overlap and Association

The management requirements for mule deer in the Bob Creek Area are somewhat different than those for elk or cattle. The mule deer population has the potential for being the least adaptable because the species concentrates on Douglas fir for winter forage from a very limited amount of available range. Management of the mule deer population at high or low densities will probably have little effect on the other ungulates; their respective niche overlaps and association should not change substantially.

The management requirements for elk and cattle are similar. They would both benefit from an increase in the key forage base if improvements are aimed at increasing the amount of tame forage and fescue available and the numbers of mutually exclusive range sites. Caution is necessary however, because increases in range sites or enhancement of existing ones may increase the amount of overlap. For example, improvements in the forage base for cattle should not initially be planned on key range sites for elk; compensatory management may be necessary if elk take too much advantage of improved range for cattle.

Concern over the amount of dietary overlap between elk and cattle is currently ameliorated by the lack of overlap in their spatial use of the range. A more intensive management system would increase the value of the range and possibly the overlap in range use between elk and cattle. This may be beneficial if it results in increased productivity; but it will require money, skill and forethought to implement.

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APPENDIX A

Range Analysis, Use and Condition

A.1 Range Analysis

Comparatively, on the 63 vegetation plots examined (Table A.1), 21,600 microplots were placed in the herbaceous layer; 480 point-to-shrub distances were measured in the shrub layer; and 500 grid points were counted in the forest layer. Collections were made of 158 of 190 species (117 genera) identified in the area during the course of the study. Summaries of the data in each range type described in Chapter 3 are listed in Tables A.2 to A.7.

A.2 Herbage Disappearance

Grassland herbage disappearance averaged 55.5%, ranging from 16.4% to 84.3% (Table A.8). Disappearance was least from the timber oatgrass phase and most from the western wheatgrass phase. The heaviest disappearance was associated with the Whaleback Ridge and least with southern third of Bob Creek. Herbage losses in the middle third of Bob Creek had the greatest variation.

A.3 Effects of Use

On each of the 266 plots examined for fecal groups, trampling damage and soil movement was recorded. (A subjective scale of none, common, widespread, and severe was used to rate these parameters.) Trampling damage was considered widespread to severe on 18.5% of all the plots. When trampling damage was associated with evidence (dung,

Table A.1 Distribution of vegetation plots in the Bob Creek Area.

Resource Parameter	Total Plots
Altitude	
1300-1400 m	11
1400-1500 m	28
1500-1600 m	19
>1600 m	5
Slope	
Gentle (0-10%)	28
Moderate (11-25%)	15
Steep (>25%)	20
Aspect	
N	9
NW	4
NE	3
W	7
E	5
SW	4
SE	7
S	9
No aspect	15
Range Type	
Grassland	21
Low shrub	10
Mixed decid. for.	13
Douglas fir for.	7
Grass/Conifer	5
Mixed forest	7

Table A.2 Species frequency and standing crops in sedge lowland and tame pasture range types in the Bob Creek Area.

Species	Plant Frequency *	
	Sedge Lowland (1)	Tame Pasture (1)
Grasses/Sedge		
Smooth brome		28
Kentucky bluegrass		26
Western wheatgrass		4
Timothy		3
Tufted hairgrass	12	
Sedge	36	
Other grasses	2	2
Forbs		
Other Forbs	3	
Shrubs		
Other shrubs	1	
Average Standing Crop (kg/ha)	---	1357

* % Frequency=total hits/100 microplots

Table A.3 Species frequency and standing crops in 3 fescue grassland phases in the Bob Creek Area.

Species	Plant Frequency *		
	Parry Oatgrass Phase (9)	Western Wheatgrass Phase (6)	Timber Oatgrass Phase (2)
Grasses/Sedge			
Richardson needle grass	4		
Western wheatgrass		1	
Sandberg bluegrass		4	
Timber oatgrass			7
June grass	2	6	
Northern wheatgrass	1	4	
Western porcupine grass	1	1	
Parry oatgrass	14	2	1
Idaho fescue	4	7	7
Rough fescue	6	3	7
Sedge	8	10	7
Other grasses	2	2	2
Forbs			
Pasture sage	2		
Oldman's whiskers	1		
Lupine	1		
Pussytoes	1		7
Moss campion		2	
Showy locoweed	1	2	
Northern bedstraw	1	2	4
Yarrow	1	1	1
Other Forbs	1	6	3
Shrubs			
Saskatoon			3
Shrubby cinquefoil			1
Creeping juniper	2	1	
Bearberry	1	1	
Rose	1	1	1
Other shrubs	1	1	1
Average Standing Crop (kg/ha)	2393	1057	715

* % Frequency=total hits/100 microplots

Table A.4 Species frequency and standing crops in 2 fescue grassland disclimax range types in the Bob Creek Area.

Species	Plant Frequency * Parry Oatgrass Disclimax (1)	Western Wheatgrass Disclimax (1)
Grasses/Sedge		
Rough fescue	1	
Richardson needle grass	1	
Sandberg bluegrass	2	
Timothy		5
Kentucky bluegrass		3
Parry oatgrass	7	1
Idaho fescue	5	1
June grass	5	10
Northern wheatgrass	1	4
Western wheatgrass	5	7
Sedge	19	2
Other grasses	4	4
Forbs		
Fleabane	4	
Oldman's whiskers	2	
Moss campion	2	
Dandelion		6
Showy locoweed		2
Red clover		1
Northern bedstraw	4	3
Pussytoes	3	6
Yarrow	2	7
Other Forbs	11	13
Shrubs		
Creeping juniper	8	
Bearberry	1	
Other shrubs	1	1
Average Standing Crop (kg/ha)	666	425

* % Frequency=total hits/100 microplots

Table A.5 Average species density, frequency, and height in low shrub range types in the Bob Creek Area.

Species (n)	Density (plants/ha)	Frequency (%)	Height (m)
Willow sub-type (7)			.8
Willow	113	49	
Birch	103	21	
Shrubby cinquefoil	53	30	
Rose sub-type (3)			.3
Rose	157	55	
Silverberry	134	37	
Chokecherry	25	7	
Gooseberry	3	1	

Table A.6 Average species basal area, plant density, and crown density in forested range types in the Bob Creek Area.

Species (n)	Basal area*	Density (plants/ha)		Crown Density
		Mature	Regen	(%)
Mixed deciduous forest(10)				75
Aspen poplar	30	2115	1300	
White spruce	t**	5	0	
Balsam poplar	t	25	0	
Douglas fir forest(5)				75
Douglas fir	52	1960	500	
White spruce	1	30	80	
Limber pine	t	0	0	
Lodgepole pine	t	25	0	
Grassland/Conifer(5)				52
Limber pine	13	860	120	
Douglas fir	3	60	25	
Mixed Forest(5)				88
Lodgepole pine	35	3020	130	
White spruce	7	510	600	
Douglas fir	3	210	20	
Aspen poplar	1	0	110	

* meters squared/ha at breast height
** t=less than .5meters squared/ha

Table A.7 Species frequency in mixed deciduous forest, Douglas fir, and mixed forest understories in the Bob Creek Area.

Species	Plant Frequency *		
	Mixed Deciduous Forest (3)	Douglas Fir Forest (2)	Mixed Forest (1)
Grasses/Sedge			
Rough fescue	1		
Hairy wild ryegrass	1	5	2
Bluejoint reed grass	1		
Bearded wheatgrass	1		1
Sedge	7		
Other grasses	2	1	1
Forbs			
Strawberry	4		2
Northern bedstraw	1		
Yarrow	1		
Other Forbs	3	1	1
Shrubs			
Buffalo-berry			3
Saskatoon	3		
Creeping juniper		3	
Bearberry		1	
Other shrubs	1	1	1

* % Frequency=total hits/100 microplots

Table A.8 Herbage disappearance from grasslands and specific locales within the Bob Creek Area.

Range	Herbage Disappearance (%)		
		Range	
	Mean	Minimum	Maximum
Sedge lowlands	---	---	---
Tame pasture	54.5	---	---
Fescue grasslands			
Parry oatgrass phase	55.1	16.4	84.3
Timber oatgrass phase	29.7	18.8	40.7
Western wheatgrass phase	64.3	44.7	82.8
Parry oatgrass disclimax	69.7	---	---
Western wheatgrass disclimax	54.4	50.3	58.4
Locale			
Lower Spring Creek	54.5	18.8	76.3
Bob Creek, South	41.0	27.4	54.5
Bob Creek, Middle	55.1	16.4	82.8
Bob Creek, North	50.3	---	---
Whaleback Ridge	69.7	55.2	84.3

tracks, beds) that cattle had used the area, 24% showed widespread to severe damage. Correspondingly, when elk or mule deer were associated with the plot, widespread to severe damage was present in 14.5% and 10.8%, respectively.

The effect of past use may be associated with the amount of pedistalling of plants and soil movement. Common to widespread degrees of pedistalling were present in 7% of all plots. Common to severe degrees of soil movement were present in 7% of all plots. When associated with a specific ungulate, pedistalling was common to widespread in 7% of the cases involving cattle, 8% of the cases involving mule deer, and 11% of the cases involving elk. Soil movement was common to severe in 6% of the cases associated with use by cattle, 5% of the cases with mule deer, and 7% of the cases with elk.

There is some indication that the activities of cattle are more damaging to the plants than those of mule deer, or elk. However, the net effect is less damaging to the soil resource, possibly because the damage occurs on sites with a lower potential of erodability and a greater potential for recovery.

The amount of damage to the soil could not be considered serious. Some areas do receive severe use by cattle, notably the banks along Bob Creek, in the middle to northern third of the allotment, where some stream siltation was noted. However, these problems are localized, and management should be able to correct them.

A.4 Range Condition

Johnston (1961) and Johnston *et al.* (1971) reported that the average basal area of Parry oatgrass exceeded the averages of all other grasses under any grazing treatment. However, the proportion of Idaho fescue never exceeded that of rough fescue except on the very heavily grazed treatment. Mueggler and Stewart (1981) described the effect of grazing as a change from rough fescue-dominated under light grazing to Idaho fescue-dominated under heavy grazing. The data on basal area composition for the Bob Creek Area appear to exhibit the characteristics of heavy grazing in that Idaho fescue is dominant (Chapter 3.3.1), and the average standing crop is indicative of the dry matter yield under moderate to heavy use (Johnston 1962).

Mitchell and Cormack (1960) felt that rough fescue had decreased in the Bob Creek Area and that grasses had a reduced cover because of overgrazing. My conversations with ranchers in the area indicate that the grassland may have had a higher proportion of rough fescue ('prairie wool') prior to the 1930's than at present. Some over-use was encouraged before the 1950's in order to reduce fire hazards. However, from 1947 to 1974, grazing in the Crowsnest Forest Reserve fell from 55,724 AUM's to 43,375 AUM's. Utilization in the Bob Creek and Lower Spring Creek allotments declined by about 1000 AUM's from 1950 (Chap. 2).

Mitchell and Cormack (1960) regarded little club moss as an indicator of poor range condition. Moss and Campbell

(1947) rated little club moss as an 'occasional' species on dry and denuded sites, changing to 'frequent' with grazing. In my investigation a significant inverse relationship exists between the amount of little club moss and the amount of litter (coefficient of determination, r=-.81; P=.05). In other words, as litter decreases, little club moss increases. The amount of litter is a function of vegetation productivity and disappearance (Dyksterhuis and Schmutz 1947). Thus, litter, little club moss and additionally bare soil cannot be considered exclusive indicators of range condition, although they may indicate a trend in vegetative cover.

The grassland in the Bob Creek Area appears to exhibit most of the characteristics of heavy grazing. The range is in predominantly fair condition (a composition rating based on the distance from climax vegetation as described by Smoliak *et al*. 1976). Good condition range may be found in the southern third of Bob Creek associated with deeded land holdings. The trend in range condition appears to have stabilized because there appear to have been no dramatic improvements since Mitchell and Cormack's (1960) investigations over 20 years ago.

APPENDIX B

Distribution of Ungulate Observations

B.1 Sample Distribution

Over the course of the study, 804 observation reports were made of 17,158 animals, and 3,111 fecal groups were counted on 208 field plots. Elk were observed 255 times, totalling 6,904 animals; 1,268 elk fecal groups were counted on 72 plots. Mule deer were observed 188 times, totalling 1,249 animals; 329 deer fecal groups were counted on 53 plots. Cattle were observed 361 times, totalling 9,005 animals; 1,514 fecal groups were counted on 83 plots. In addition, 36 composite samples of 1,800 fecal groups were collected for an analysis of diets (18 samples of elk feces, 6 of mule deer feces, and 12 of cattle feces).

Most observations (83.7%) were made within or beside a stationary vehicle. The animals were usually (65%) 250 m or further from the observer and generally (79.3%) showed no behavioural change associated with the observers presence.

Animal observations were made on 56% (262 cells) of the study area. These were evenly divided between the east and west (48.9% west) but slightly favoured the southern and central portions (58.4% south; 65.8% within 4.3 km of the study area's centre).

The distribution of observation reports and field plots is shown in Table B.1. Animals were observed in all seasons, usually at dawn and mid-morning, between 1400 m and 1500 m altitude, on gentle south facing, open grassland slopes. Fecal group plots were somewhat more evenly distributed in comparison to animal observations.

Table B.1 Animal range use sample distribution.

Resource Parameter	Animal Observations	Fecal Group Plots
Season		
Spring	158	---
Summer	236	---
Fall	208	---
Winter	202	---
Time-of-Day		
Dawn	198	---
Midmorning	213	---
Noon	138	---
Afternoon	138	---
Dusk	102	---
Missing Data	15	---
Altitude		
1300-1400 m	202	9
1400-1500 m	339	72
1500-1600 m	224	97
>1600 m	39	23
Missing Data	0	7
Slope		
Gentle (0-10%)	494	105
Moderate (11-25%)	231	61
Steep (>25%)	79	42
Aspect		
N	5	13
NW	16	5
NE	7	17
W	90	20
E	70	13
SW	156	23
SE	129	38
S	213	60
No aspect	118	19
Range Type		
Grassland	601	137
Low shrub	64	3
Mixed decid. for.	41	23
Douglas fir for.	6	18
Grass/Conifer	89	20
Mixed forest	3	7

Table B.2 Temporal distribution of observations and total animals sighted in the Bob Creek Area.

	Elk		Mule Deer		Cattle	
		Total		Total		Total
	Obs.	Head	Obs.	Head	Obs.	Head
Season						
Spring	92	731	49	262	17	457
Summer	2	39	21	47	213	5504
Fall	17	400	63	241	128	3020
Winter	144	5734	55	699	3	24
Time-of-day						
Dawn	41	1863	63	380	94	1844
Midmorning	71	2176	47	303	95	1556
Noon	21	657	17	68	100	3063
Afternoon	60	1068	29	292	49	1915
Dusk	51	766	28	195	23	627
Deleted*	11	374	4	11	0	0
Total	255	6904	188	1249	361	9005

* Missing data. Percentages and averages are calculated from the remaining data set.

Table B.3 Observed activity of elk, mule deer and cattle.

Activity	Observations (%)		
	Elk	Mule Deer	Cattle
Foraging	65.9	54.3	69.0
Travelling	9.4	19.7	5.8
Bedded/Ruminating	15.7	4.3	22.2
Disturbed	7.5	21.3	3.0
Other	1.6	.5	0.0

Table B.4 Topographical distribution of elk on the Bob Creek Area.

Resource Parameter	Observations (%)	Fecal Group Counts (%)
Altitude		
1300-1400 m	8.2	1.0
1400-1500 m	33.3	24.9
1500-1600 m	48.2	52.3
>1600 m	10.2	21.8
Slope		
Gentle (0-10%)	49.4	17.5
Moderate (11-25%)	39.6	52.9
Steep (>25%)	11.0	29.6
Aspect		
N	1.2	4.9
NW	1.6	2.6
NE	.4	7.4
W	10.6	19.1
E	11.0	7.1
SW	26.3	12.7
SE	20.4	18.5
S	27.5	27.8
No aspect	1.2	4.8

Table B.5 Topographical distribution of mule deer on the Bob Creek Area.

Resource Parameter	Observations (%)	Fecal Group Counts (%)
Altitude		
1300-1400 m	36.7	.7
1400-1500 m	33.5	36.6
1500-1600 m	26.1	53.7
>1600 m	3.7	9.1
Slope		
Gentle (0-10%)	59.0	47.1
Moderate (11-25%)	26.6	13.4
Steep (>25%)	14.4	39.5
Aspect		
N	1.1	9.7
NW	1.6	4.3
NE	1.6	4.6
W	8.0	2.1
E	10.1	1.2
SW	18.1	2.7
SE	13.3	27.7
S	33.5	46.2
No aspect	12.8	1.5

Table B.6 Topographical distribution of cattle on the Bob Creek Area.

Resource Parameters	Observations (%)	Fecal Group Counts (%)
Altitude		
1300-1400 m	31.0	4.7
1400-1500 m	52.9	51.9
1500-1600 m	14.4	37.6
>1600 m	1.7	5.8
Slope		
Gentle (0-10%)	71.2	68.7
Moderate (11-25%)	22.2	21.5
Steep (>25%)	6.6	9.8
Aspect		
N	0.0	1.5
NW	2.5	.7
NE	.8	10.0
W	13.3	5.3
E	6.4	3.1
SW	15.2	14.9
SE	14.4	12.6
S	22.2	35.1
No aspect	25.2	16.9

Table B.7 Distribution of elk in relation to vegetation on the Bob Creek Area.

Resource Parameters	Observations (%)	Fecal Group Counts (%)
Range Type		
Grassland	79.6	82.7
Low shrub	2.4	.1
Mixed decid. for.	1.6	.6
Douglas fir for.	1.2	4.8
Grass/Conifer	15.3	11.4
Mixed Forest	0.0	.4
Adjacent Range Type		
Grassland	16.9	3.1
Low shrub	10.2	8.2
Mixed decid. for.	29.0	11.0
Douglas fir for.	22.0	17.0
Grass/Conifer	12.9	30.2
Mixed Forest	8.2	30.4
Distance to trees		
0-25 m	49.4	6.6
25-100 m	44.3	41.4
100-250 m	6.3	51.6
250-500 m	0.0	.4
>500 m	0.0	0.0
Distance to shrubs		
0-25 m	57.3	---
25-100 m	40.0	---
100-250 m	2.7	---
>250 m	0.0	---

Table B.8 Distribution of mule deer in relation to vegetation on the Bob Creek Area.

Resource Parameters	Observations (%)	Fecal Group Counts (%)
Range Type		
Grassland	56.4	66.9
Low shrub	15.4	.3
Mixed decid. for.	8.5	7.9
Douglas fir for.	1.6	10.0
Grass/Conifer	17.6	14.3
Mixed Forest	.5	.6
Adjacent Range Type		
Grassland	31.4	8.5
Low shrub	13.8	.3
Mixed decid. for.	21.3	2.4
Douglas fir for.	11.2	19.5
Grass/Conifer	17.0	57.8
Mixed Forest	5.3	11.6
Distance to trees		
0-25 m	48.9	20.4
25-100 m	33.5	38.3
100-250 m	13.3	41.3
250-500 m	4.3	0.0
>500 m	0.0	0.0
Distance to shrubs		
0-25 m	74.5	---
25-100 m	21.3	---
100-250 m	2.7	---
>250 m	1.6	---

Table B.9 Distribution of cattle in relation to vegetation on the Bob Creek Area.

Resource Parameters	Observations (%)	Fecal Group Counts (%)
Range type		
Grassland	80.9	89.6
Low shrub	8.0	.3
Mixed decid. for	5.1	3.7
Douglas fir for.	0.0	3.9
Grass/Conifer	4.7	2.0
Mixed forest	.6	.5
Adjacent Range type		
Grassland	16.1	4.3
Low shrub	20.5	15.5
Mixed decid. for.	41.8	8.3
Douglas fir for.	2.5	18.4
Grass/Conifer	14.7	36.4
Mixed forest	4.4	17.2
Distance to trees		
0-25 m	29.4	9.9
25-100 m	43.5	37.0
100-250 m	17.5	33.8
250-500 m	7.8	19.3
>500 m	1.9	0.0
Distance to shrubs		
0-25 m	52.4	---
25-100 m	38.8	---
100-250 m	7.2	---
250-500 m	1.7	---

APPENDIX C

Animal Response

Table C.1 Elk activity in response to temporal and topographic factors.

Resource Parameter	Activity Response Coefficient*				
	Foraging	Travel	Bedded	Other	Disturb
Season					
Winter	1.31	-3.40	3.81	-1.23	-0.49
Spring	5.73	.80	-9.07	-0.02	2.57
Summer	-60.46	-12.73	33.37	48.17	-8.35
Fall	-34.95	25.95	12.89	4.90	-8.78
Time-of-day					
Dawn	18.52	0.16	-10.87	-1.14	-6.68
Mid-morning	-10.89	-0.70	5.83	-1.38	7.15
Noon	-23.29	11.68	8.43	-3.21	6.39
Afternoon	-6.32	2.23	4.41	0.50	-0.81
Dusk	12.44	-5.04	-6.54	3.72	-4.58
Altitude					
1300-1400 m	19.02	-4.60	-10.57	-0.89	-2.95
1400-1500 m	1.63	-0.36	2.64	-0.14	-3.79
1500-1600 m	-3.39	1.33	-0.91	0.88	2.09
>1600 m	-6.72	-0.94	5.41	-2.99	5.24
Slope					
Gentle	-10.61	1.07	9.65	-0.77	.65
Moderate	10.36	-0.84	-9.28	.45	-0.69
Steep	10.38	-1.78	-9.96	1.82	-0.45
Aspect					
N	5.64	24.06	-22.39	-0.75	-6.56
NW	14.33	-5.51	-3.87	-1.01	-3.94
NE	-56.71	-10.13	72.02	-0.67	-4.32
W	-7.90	-1.62	6.99	-1.93	4.66
E	6.11	1.19	-16.06	-0.86	9.62
SW	5.61	-3.25	2.20	-0.26	-4.30
SE	-4.69	-0.56	3.16	-1.82	3.91
S	-2.01	2.13	.57	2.83	-3.53
No aspect	11.43	22.65	-26.80	-1.01	-6.28

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.2 Mule deer activity in response to temporal and topographic factors.

Resource Parameter	Activity Response Coefficient*				
	Foraging	Travel	Bedded	Other	Disturb
Season					
Winter	11.58	-11.36	-1.47	-0.62	1.87
Spring	.53	12.95	.28	-0.75	-13.02
Summer	-16.75	9.80	-6.10	4.28	8.76
Fall	-4.94	-3.43	3.10	-0.31	5.58
Time-of-Day					
Dawn	5.36	4.42	-3.65	-0.37	-5.76
Mid-morning	-1.98	-0.41	2.74	1.58	-1.93
Noon	-20.35	3.77	13.89	-1.11	3.80
Afternoon	-6.40	-8.57	-3.45	-0.81	19.23
Dusk	8.15	-3.31	-0.73	-0.34	-3.78
Altitude					
1300-1400 m	-10.95	7.17	-3.22	-0.36	7.36
1400-1500 m	7.37	-4.20	3.17	.64	-5.70
1500-1600 m	11.03	-8.82	.95	-0.62	-2.54
>1600 m	-20.50	21.92	-2.58	-0.77	1.93
Slope					
Gentle	-3.89	1.47	.74	.01	1.66
Moderate	1.03	-0.70	1.34	1.06	-0.05
Steep	14.09	-4.76	-0.58	2.01	-6.74
Aspect					
N	-57.74	33.04	-8.17	.10	32.76
NW	31.77	-11.89	-5.61	.07	-14.34
NE	.08	20.72	-6.30	.42	-14.91
W	2.60	9.17	8.51	-0.40	19.88
E	5.16	8.10	-3.26	-0.28	-9.72
SW	5.60	.85	-1.16	.12	-5.41
SE	-15.93	4.16	-4.79	-0.19	6.75
S	11.54	-12.86	2.34	.19	-1.22
No aspect	-26.52	1.80	-0.04	-0.07	24.88

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.3 Cattle activity in response to temporal and topographic factors.

Resource Parameter	Activity Response Coefficient*			
	Foraging	Travel	Bedded	Disturb
Season				
Spring	5.80	11.0	-13.65	-3.15
Summer	-0.97	-0.48	2.35	-0.90
Fall	.17	-0.55	-1.62	2.00
Winter	28.84	-4.84	-20.52	-3.48
Time-of-day				
Dawn	13.97	-1.12	-10.24	-2.60
Mid-morning	2.52	-2.71	1.07	-0.87
Noon	-16.81	3.64	11.6	1.56
Afternoon	-9.94	.91	4.27	4.77
Dusk	26.76	-1.91	-22.08	-2.71
Altitude				
1300-1400 m	8.09	2.39	-9.32	-1.17
1400-1500 m	-2.94	-0.65	2.41	1.17
1500-1600 m	-5.33	-2.18	8.91	1.39
>1600 m	-11.37	-5.14	19.98	-3.47
Slope				
Gentle	-6.56	.72	5.00	.83
Moderate	16.87	3.81	-11.28	-1.78
Steep	13.99	4.91	-15.98	-2.99
Aspect				
NE	3.51	26.43	-25.66	-4.27
NW	-6.11	-4.38	12.74	-2.26
E	-21.37	4.93	10.20	6.24
W	-3.63	-3.47	9.86	-2.76
SE	8.24	-1.67	-5.54	-1.03
SW	11.36	-4.00	-7.27	-1.09
S	4.70	.47	-7.20	2.04
No aspect	-7.90	3.11	5.70	-0.90

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.4 Elk activity in response to vegetation.

Resource Parameter	Activity Response Coefficient*				
	Foraging	Travel	Bedded	Other	Disturb
Range type					
Grassland	-4.52	0.77	.67	.53	2.55
Low shrub	6.44	1.43	8.27	-4.12	-12.02
Mixed deciduous forest	-4.02	8.51	18.84	-6.33	-17.00
Douglas fir forest	-28.25	50.47	1.49	-6.98	-16.73
Grass/Conifer Mixed Forest	25.14	-9.00	-6.81	-0.94	-8.39
Adjacent Range Type					
Grassland	-34.28	6.72	12.37	4.40	10.79
Low shrub	19.92	-5.36	-5.81	-1.15	-7.60
Mixed deciduous forest	7.31	1.85	-2.44	-2.05	-4.68
Douglas fir forest	-2.08	-4.07	-0.07	-0.10	6.32
Grass/Conifer	5.48	1.48	-2.49	.98	-5.45
Mixed forest	16.91	-4.73	-5.43	-1.64	-5.12
Distance to trees					
0-25 m	-1.24	-0.13	.99	1.26	-0.89
25-100 m	1.84	1.06	-1.75	-1.32	.17
100-250 m	-3.18	-6.46	4.53	-0.65	5.76
Distance to shrubs					
0-25 m	-2.11	.19	2.80	-0.25	-0.63
25-100 m	1.81	-0.14	-2.86	.45	.74
100-250 m	17.70	-1.94	-16.68	-1.30	2.23

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.5 Mule deer activity in response to vegetation.

Resource Parameter	Activity Response Coefficient*				
	Foraging	Travel	Bedded	Other	Disturb
Range type					
Grassland	11.00	-1.60	1.15	-2.02	-8.53
Low shrub	-9.37	-1.58	-6.23	.59	16.58
Mixed deciduous forest	-26.12	.25	-10.87	2.06	34.68
Douglas fir forest	-71.04	62.02	24.24	2.03	-17.26
Grass/Conifer	-5.80	.89	5.24	4.68	-5.02
Mixed forest	-72.44	-3.59	-13.02	3.16	85.90
Adjacent Range type					
Grassland	11.16	-4.77	6.43	-3.29	-9.54
Low shrub	-17.04	11.05	2.80	.33	2.86
Mixed deciduous forest	-15.15	-3.72	-1.86	1.16	19.07
Douglas fir forest	1.37	-1.36	-7.62	4.26	3.35
Grass/Conifer	13.24	4.45	-5.82	1.20	-13.07
Mixed forest	-6.22	.91	-3.21	1.15	7.37
Distance to trees					
0-25 m	5.34	-11.69	2.47	-0.70	4.58
25-100 m	-7.28	16.85	-0.82	.41	-9.16
100-250 m	-2.54	5.50	-4.62	.98	.67
250-500 m	3.84	-15.41	-7.56	1.75	17.38
Distance to shrubs					
0-25 m	1.68	.37	-0.14	.30	-2.21
25-100 m	-4.59	-5.69	.32	-0.81	10.78
100-250 m	2.43	18.26	-2.52	-0.66	-17.51
250-500 m	-21.18	28.10	6.44	-1.98	-11.38

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.6 Cattle activity in response to vegetation.

Resource Parameter	Activity Response Coefficient*			
	Foraging	Travel	Bedded	Disturb
Range type				
Grassland	1.88	1.60	-2.59	-0.89
Low shrub	-5.27	-5.47	7.08	3.66
Mixed deciduous forest	-9.62	-9.73	8.87	10.48
Douglas fir forest				
Grass/Conifer	-3.39	-10.74	17.62	-3.49
Mixed forest	-68.10	39.26	32.32	-3.49
Adjacent Range type				
Grassland	-1.91	4.48	-1.51	-1.06
Low shrub	-13.31	-1.18	10.67	3.83
Mixed deciduous forest	2.29	.54	-3.10	.27
Douglas fir forest	-3.06	6.59	0.00	3.52
Grass/Conifer	16.83	-4.30	-9.43	-3.10
Mixed forest	-7.17	-5.33	16.63	-4.13
Distance to trees				
0-25 m	-0.94	2.95	.70	3.19
25-100 m	-0.47	.14	.42	-0.09
100-250 m	1.77	3.35	-3.02	-2.11
250-500 m	2.38	-2.31	5.35	-5.41
>500 m	-0.71	20.59	-14.28	-5.60
Distance to shrubs				
0-25 m	1.97	3.39	-3.68	-1.68
25-100 m	-1.28	-3.98	3.84	1.42
100-250 m	-5.72	-5.05	6.54	4.23
>250 m	-7.41	8.04	-2.14	1.52

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.7 Elk activity in response to environmental gradients.

Resource Parameter	Activity Response Coefficient*				
	Foraging	Travel	Bedded	Other	Disturb
Shade cover					
None	.43	.28	2.81	-1.51	-2.01
Partial	-9.82	-3.12	-2.23	-0.85	16.02
Total	1.91	.48	-1.99	1.54	-1.94
Snow depth					
0	5.53	-0.53	-5.30	1.50	-1.20
.1-1 dm	-15.54	3.71	8.10	-1.41	5.15
1.1-2 dm	-26.74	-1.34	26.89	-1.88	3.07
2.1-4 dm	-6.47	4.99	-6.33	-1.83	9.64
4.1-6 dm	-1.08	-6.72	13.56	-2.10	-3.66
6.1-8 dm	17.78	-6.78	-4.41	-2.23	-4.37
>8.1 dm	8.83	-3.62	1.55	-0.82	-5.93
Distance to water					
0-25 m	-51.83	15.94	47.22	-0.30	-11.03
25-100 m	-6.58	3.41	-4.73	-2.43	10.33
100-250 m	4.79	-1.03	-2.39	.16	-1.53
250-500 m	5.36	-1.32	-4.99	1.55	-0.65
500 m - 1 km	-5.06	-0.37	9.78	-1.34	-3.02
Distance to salt					
25-100 m	-9.76	78.30	-55.37	-1.92	-11.24
100-250 m	18.15	24.26	-27.27	-0.94	-14.19
250-500 m	-35.90	7.60	7.73	13.04	7.53
500 m - 1 km	-9.85	31.42	-11.56	-2.39	-7.62

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.8 Mule deer activity in response to environmental gradients.

Resource Parameter	Activity Response Coefficient*				
	Foraging	Travel	Bedded	Other	Disturb
Shade cover					
None	3.67	-1.73	-1.99	-0.45	.49
Partial	-26.14	-1.77	11.69	5.11	11.11
Total	2.87	1.06	-1.13	-0.68	-2.11
Snow depth					
0	-1.90	1.82	1.22	.24	-1.39
.1-1 dm	-1.30	-4.81	-1.57	-1.45	8.85
1.1-2 dm	-18.97	17.99	-3.33	.82	3.50
2.1-4 dm	-8.84	-22.72	-6.61	-0.96	39.13
4.1-6 dm	37.05	-21.31	-4.55	-0.55	-10.65
6.1-8 dm	34.63	-21.75	-4.31	-0.08	-7.75
>8 dm	36.03	-19.64	-3.23	-1.17	-12.00
Distance to water					
0-25 m	-18.01	-7.02	-3.96	-0.27	24.27
25-100 m	-9.10	-6.57	-3.56	-1.62	20.85
100-250 m	-4.05	.59	1.52	-0.32	2.25
250-500 m	4.07	.75	.94	-0.33	-5.43
500 - 1 km	8.87	5.66	-0.23	2.89	-17.20
Distance to salt					
0-25 m	-16.90	24.66	-4.95	.04	-2.85
25-100 m	-5.49	.78	-3.48	-0.66	8.86
100-250 m	10.73	-12.53	-5.12	-1.40	8.32
250-500 m	-32.54	4.17	-7.57	-2.25	38.19

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.

Table C.9 Cattle activity in response to environmental gradients.

Resource Parameter	Activity Response Coefficient*			
	Foraging	Travel	Bedded	Disturb
Shade cover				
None	-4.94	1.06	4.84	-0.97
Partial	-8.62	-5.97	15.14	-0.55
Total	6.56	.06	-7.69	1.07
Snow depth				
0 dm	.37	-1.33	.97	-0.02
.1-1 dm	-11.81	17.89	-4.69	-1.38
1.1-2 dm	-24.39	44.08	-16.50	-3.19
2.1-4 dm	41.47	-1.81	-40.42	.76
Distance to water				
0-25 m	-24.62	3.43	18.52	2.68
25-100 m	-2.29	-1.47	2.22	1.53
100-250 m	4.17	.89	-5.14	.08
250-500 m	8.76	.44	-7.76	-1.44
>500 m	-6.87	-5.13	14.88	-2.88
Distance to salt				
0-25 m	-65.05	-2.10	67.99	-0.85
25-100 m	-14.56	-5.30	22.68	-2.83
100-250 m	-13.55	14.64	1.03	-2.12
250-500 m	-4.89	1.46	6.32	-2.89
>500 m	-4.21	-4.35	5.39	3.16

* MNA coefficient of response. Each set of coefficients sums to 0 on a horizontal axis. Each coefficient may be interpreted as a likelihood of occurence of an activity.